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ON STOCKTON BATES' SUPPORT FOR SPINNING SPINDLES.

[Report of the Committee on Science and the Arts.]

[No. 1554.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, June 28, 1890.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred for examination,

STOCKTON BATES' PATENTED SUPPORT FOR SPINNING SPINDLES,

respectfully report that:

They have carefully examined the same and investigated the state of art under which the invention was made, and find as follows:

That the invention is the subject of Letters-Patent of the United States, No. 416,286 and No. 416,287, both dated December 3, 1889, and granted to Stockton Bates, Edwin F Shaw and George M. Von Culin.

That its purpose is to furnish a better support in which spinning spindles revolve, and whilst supporting the spindle, so as to diminish and avoid the inaccuracies in the rotation due to the springing from unequal tension of the driving-bands, to also furnish more durable wearing surfaces, easily and cheaply replaced when worn, and to provide an efficient means of constant lubrication and exclusion of foreign substances from the wearing surfaces. In addition to these features, the bearings, by reason of their construction, require less framing to support them and are entirely self-contained, and hold their several parts in correct relative position to each other, irrespective of any changes which may occur in the shape of the supporting frame of the machine.

In order that the features of importance and value in this invention may be more clearly understood, your Committee deem it expedient to briefly describe how such spindles were heretofore supported in pre-existing machines for the same purpose, and also to show the beneficial effects which may reasonably be expected from their introduction into use.

The functions of spinning spindles are two-fold. They twist a filament or sliver of roving or carded cotton, which has been stretched out, but not yet twisted, and wind it upon a tube placed upon the spindle, forming what is known as a cop.

In the spinning of yarn, as practised in olden times in every household, the spindle revolved with the flyer or frame, bearing hooks, over one of which the yarn passed to the spool on the spindle, turned with a slightly greater velocity, and this difference produced the winding effect.

In the ordinary spinning wheel the spindle was horizontal, and supported in bearings at each end; the speed attainable by foot-power was limited and never brought out any test of the durability and capacity for work which developed in manufactures as conducted by water and steam-power.

In machine spinning, on the other hand, the spindles are vertical or nearly so.

Power spinning machines may be classified as fol-

lows: Throstle spinning, which resembles the method of the spinning wheel, using a flyer and bobbin; mule spinning, in which a certain length of sliver is paid out by rollers, and stretched and spun, and then wound upon the bobbins; and ring spinning, in which a spindle, revolving rapidly, turns a bobbin with it, inside of a ring having a rim or lip, around which a small loop of metal called a traveller turns, and guides the yarn, as it is twisted, from a sliver of roving, which is steadily stretched and paid out by a series of rollers in the upper part of the machine. The frictional resistance of the traveller upon the ring causes it to turn more slowly than the spindle and bobbin, and as a consequence the yarn winds on the bobbin. The rate of winding is regulated by the weight or size of the traveller. The ring and traveller have a slow up-and-down motion during this operation which causes the yarn to wind evenly on the bobbin. The spindle and bobbin must be concentric with the ring or else a tightening and loosening effect is produced at every revolution, which prevents the equal twisting of the yarn and uniform winding of the cop.

The practice which has prevailed in making and supporting machine spinning spindles, has been to rest the lower end in a step set in a rail, and with a journal above fitting through another rail, known as a bolster rail; rotary motion is imparted to the spindle by a grooved pulley or whirl, turned by an endless band. In ring spinning frames the rings are in another rail, which works slowly up and down in suitable guides, so as to wind the yarn evenly in the cops.

It is obvious that any warping or springing of either of the rails must impair the alignment of the bearings of the spindles, and such impairment of position of the bearings increases the friction, and retards the motion and causes both a diminished quantity and poorer quality of product. Such bearings are exposed to dust and require frequent lubrication.

The invention under consideration is designed to avoid the possibility of such defects and as hereinbefore stated, to secure perfect cleanliness and automatic lubrication, besides facility of adjustment and repair. (*See frontispiece.*)

The Bates spindle support consists of an upper section (*1*), which fits from below through an opening in the single rail (*2*) of the machine frame, resting with a shoulder against the under side of the rail, being drawn up and held in position by a nut (*3*) upon the upper part. An oil receptacle (*4*) is formed around the central portion of the upper part of the bearing, within the shoulder, which receives an absorbent packing, and is in fluid communication with an oil-space in the central cavity, containing the upper bush or bearing (*5*). A lower section (*6*) is screwed into the bottom of the upper section, containing the lower bush or bearing (*7*) and the bottom or end-bearing (*8*) and an oil receptacle. In the upper section (*1*), which is bored out concentrically with the screw and shoulder already referred to, is inserted the upper bushing or sleeve (*5*), extending downwardly into a chamber (*10*) formed in the upper side of the whirl (*9*). A steel plate (*11*) is inserted in the bushing (*5*) on the side receiving the draft of the driving-band, with a wooden strip (*12*) laid under it. The whirl (*9*) has apertures (*13*) made through it, reaching from the upper cavity (*10*) into the lower cavity, through which oil can descend, but cannot be whirled off by reason of the lower rim (*14*) of the whirl extending into a chamber formed in the lower part of the support. A bushing (*7*) removably fitted into the lower part of the support, serves to centre the lower end and a hardened steel plate (*8*), beneath the spindle, supports the weight. The bushings (*5*) and (*7*), which form the bearings, are not made with continuous outer surfaces to fit in the casing portions of the support, but are fluted or grooved so as to provide oil channels (*15*) and (*16*) and chambers between the bushing and the casings.

Below the hardened steel bearing (*8*) there is a cavity (*17*), into which any foreign substances in the oil can subside without injury to the bearing. A cap (*20*), fitted loosely around the spindle (*19*) at the top of the bearing (*1*) serves to exclude dust, and is easily raised by the spout of the oiler. An oil-chamber (*4*) is formed around the bearing, which being filled with an absorbent, saturated with oil, insures continuous lubrication for a long time.

The portion of the bearing surrounding the whirl is

formed with curved pillars and intervening open spaces so as to permit easy access to the whirl for the driving-band, and to afford opportunity for inspection.

An elastic plate of metal (*26*), secured by a screw to the upper part of the bearing at the rear, and extending across the upper surface of the whirl, with a projecting ear at the front, acts as a brake when pressed against the whirl, so that the motion of any spindle can be arrested without affecting that of any other.

It will be seen upon inspection that the spindle is supported through a large portion of its length, down to the portion which the driving band strains upon the whirl, and cannot therefore be sprung or vibrated by the band. The oil is guided steadily from the top to the bottom of the bearing, as the oil chambers are sufficient in size to retain oil for several weeks' running. As a matter of fact, these spindles have been run for six weeks at full speed with only one oiling, as a test, lagging only during the last week. It is found to be safe practice to oil them once per fortnight. Ordinary spindles require oiling at least every two days, usually daily and even oftener.

The bushings in the upper and lower parts of the bearings are easily removed and replaced, and being finished with their internal and external surfaces concentric, they cannot be wrongly adjusted. From their form they are cheaply made accurately interchangeable, so that once fitted with these bearings, a spinning frame can, at low cost, be kept in best efficiency for an unlimited time. When once adjusted concentrically with the rings of the spinning frame, all parts, except the upper shell and nut, may be removed without impairing the adjustment and the bearing may be replaced without interrupting the work of contiguous spindles.

The spindle is so well supported in these bearings as to be incapable of vibration, and once set true with the ring in which it works, it continues to work true.

The speed to which these spindles can be run without heating is far beyond the limit imposed by the properties of the staple to be spun. This, it seems, leaves nothing further

to be desired in respect of speed. All portions of this spindle-support are made to fit concentrically and exact alignment is thus enforced. The finishing of the parts is entirely within the capacity of turret lathes, and can, therefore, be made at low cost, and the parts subject to wear, to-wit, the bushings involve very little material and are easily fitted or finished at slight cost.

Your Sub-Committee have examined many other spindle supports and spindles, and have found nothing comparable with the construction exhibited in the Bates spindle. The proportions and combinations of its several parts are so well arranged, that in repeated trials, a spindle weighing about four ounces was kept running for a period of three weeks, or 180 hours, at 12,000 revolutions per minute, without heating the bearings, with no perceptible vibration, and with only the oil supplied at the outset. Appended to this report* is a statement of trials and observations made by Mr. S. Webber, which, while not entirely satisfactory for reasons which Mr. Webber has been careful to explain in his postscript, are of interest to those familiar with such manufactures, as indicating that not only can improved quality of product, with less waste of material, and greater capacity of machine with the same labor, be procured, but that an economy of driving power should result from the use of the invention.

The invention, as observed at work by your Committee, appears to be simple and effective, of great durability, of easy adjustment, susceptible of renewal of all the wearing parts in each spindle without the trouble of readjustment, and without involving any suspension of the work of other parts of the machine, and for this reason, together with the high speed at which it can safely be run, the invention increases the capacity of the machinery to the limit imposed by the properties of the staple. Furthermore, it secures such a uniform spinning and winding by reason of its accuracy of motion, that the best possible quality of product from the material results, as well as the greatest quantity

* Not published.

in a given time, without requiring any additional labor. Thus the invention economizes cost of production, and since the advantages for such reduced cost for labor in proportion to the product, and such improvement in product, are followed by better weaving and better quality of cloth, with diminished cost, the invention may be fairly considered as a most valuable accession to the comfort of mankind in their second great want—*clothing*—food only taking precedence. In view of these facts, the award of the ELLIOTT CRESSON MEDAL appears to be merited.

FRANCIS LECLERE,
Chairman.
PHILIP H. FOWLER,
LUTHER L. CHENEY,
[SIGNED] JOHN HALL,
S. LLOYD WIEGAND,
STANLEY LEES,
W. BARNET LEVAN,
SAMUEL WEBBER.

Adopted, June 20, 1890.

[SIGNED] GEO. A. KOENIG,
Chairman pro tem., Com. Science and the Arts.

MODERN CONCEPTIONS OF ELECTRICITY.

BY DR. LOUIS DUNCAN.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *February 3, 1890.*]

DR. DUNCAN was introduced by PROF. E. J. HOUSTON of the INSTITUTE, and spoke as follows:

MEMBERS OF THE INSTITUTE AND LADIES AND GENTLEMEN:

I will try to tell you to-night what I think some other people believe with respect to electricity, or at least I will give so much of their belief as I hold to be sound. But we must begin at some little distance from the main title of my paper, for we will find, I think, that to understand the nature of electrical action we must first understand the general type of the various actions which go on around us.

For the industrial life of mankind is made up of two things, the transformation of material and the transformation of energy. All of our endeavor, all of our labor is only to make more useful to us the things we have already on the earth. The supply of material in the world is practically constant; nothing drops off of it as we whirl through space, and the only thing added is some stray meteorite, insignificant except in the way of a sign or wonder. And it has been known for a great many years that mankind cannot destroy or create matter. So we must be content to take what has been given us, and with a little earnest jugglery to change a mountain into a steamboat, to change dirt into a plate-glass mirror, and to make sugar out of coal tar.

But with respect to energy the case is somewhat different. The earth is constantly receiving energy, constantly losing it, and the amounts very nearly balance. It would be very unfortunate, indeed, if we were for one day to fail to receive our accustomed supply of energy from the sun, and it would be extremely uncomfortable if all the energy received for twenty-four hours were to be bottled up on the earth and not allowed to escape. For the sun supplies the energy that makes life possible here. Although the supply is not constant, yet as far as we are concerned or any agency we are acquainted with is concerned, the same law of limitation holds as holds for matter—we cannot create energy—we cannot destroy it. But we spend a great deal of time in transforming it. By the stored energy in the coal we drive our engines; all artificial light is energy transformed from coal, or oil, or wood to the energy of luminous radiations. And all of the energy we utilize we can trace directly or indirectly to the sun. It is the heat of the sun which causes the chemical changes which make up the growth of plants, and this energy remains in the plant after it has become fossilized and appears again as heat when we burn the coal. The energy of our rivers and streams comes from the sun, too—for its heat vaporizes the water of the ocean and makes the winds which carry it over the land where it falls as rain, and flowing to the ocean again, runs

our mills and factories. The sun is the universal source of energy, and so of life on the earth, and this energy comes to us as radiations, heat and light as we call them when they have suffered other transformation, and as I shall hope to partly prove that these radiations are really electrical, then we see that we have been unconsciously very dependent on electricity, although it is the fashion to speak of it as a matter still in its infancy.

The solar system is losing its energy. There exists to-day not one two-hundredths of the amount which existed when the system was created, and it is a curious question as to where the rest has gone. Perhaps it has helped to make up new systems and worlds, perhaps, beyond the confines of what we call space, the law of conservation no longer holds and the energy is annihilated.

The electrician is mainly concerned with the transformations of energy, and material only affects him as it modifies these transformations. The principal virtue of electrical applications lies in the ease with which they allow transformations otherwise difficult to be made. For example, I have here some pieces of apparatus which will illustrate this. Motor, Geissler tubes, piece of carbon, induction coil and jars. What we want to understand is how this transmission takes place.

For the last half century, the great advances in physical science have been through the application of the law of the conservation of energy. Energy disappears at one place and appears in another form, perhaps in another place. The two quantities are equal, or if they are not equal the difference must be accounted for by some loss which must be discovered. The law leads readily to equations, and these have given results of great importance. But, in the last few years, the attempt has been made to trace the path of the energy, which leaving one place, appears at another. We try to label a given portion of energy—the energy in a given piece of coal, say—and to follow it into the boiler, and then to the engine, and then, perhaps, to a dynamo, and, finally, as electric energy to this electric lamp. It has suffered a number of changes, it has passed through many

forms, but, finally, that individual portion of energy has reached the lamp, and being changed into radiations, has started on a journey causing a shudder of the ether through the universe and reaching the confines of space.

It is by tracing these various actions that we have arrived at our present notions, and we have traced them backward, beginning with the energy after it has become radiant.

Ever since the undulatory theory of light began to be held, it became evident that there must be some substance, pervading all space, which would transmit the vibrations which constitute light. It is evident that if light is vibratory, something must vibrate, and as there is no matter in the space between the earth and the other heavenly bodies, there must be something besides matter filling the space. This hypothetical substance was named the ether, and every later discovery has added evidence as to its existence, until now we may consider the ether as a proven fact. And in late years the notion of the ether has assumed greater and greater importance. Sir William Thomson has advanced the theory that matter itself is but ether under various conditions of motion, and he, together with J. J. Thomson, has in some way proved it. If we can account for matter by modifications of the ether, then ether and energy, with the phenomena incident to them, may give us an entire mechanical explanation of the universe, and we can believe that, as far as this mechanical explanation is concerned, we need but ether and motion. And the importance of the ether to us, to-night, is this, that it seems more than probable that all electrical actions of whatever kind, and however made apparent, are transmitted through the ether and by it; and, indeed, the term electricity itself may very well be a misnomer, and electricity positive and negative may only be two phases of the ether.

This etheric theory is an attractive one. To unify all the phenomena of nature and to refer them to the same cause has been the dream of philosophers for many years. But although the conception is simple enough, the details are to us very complex, partly perhaps, because we are ourselves entangled

in that very complicated modification of ether called matter, and cannot perceive things which in their essence are only too simple for us to grasp.

In order to appreciate the change which has taken place in electrical ideas, let us briefly examine the old notions of what constituted the charge of a condenser, and of how electrical energy was conveyed by a wire. In the first case it was held that when we charged a Leyden jar there was a certain definite amount of the fluid electricity upon it, positive electricity on one coating, negative upon the other. When the jar is discharged the two fluids rush together and neutralize one another with some little noise and heat. The thoughts of the experimenters were concentrated upon the charged bodies. If there were two of them they attracted or repelled one another, this was the important fact. It remained for Faraday to show that the space around a charged body had an important part to play in the phenomenon. Substituting sulphur for air between the coatings of a condenser he proved that the capacity was greatly changed. From that time more and more attention has been paid to the space around charged bodies and less to the bodies themselves, until we have begun to consider the latter as simply serving to make evident to us something which is taking place in the surrounding space. But we will talk further of this in the light of some experiments which I will try later.

Our views about an electric current have also been profoundly changed, but much more lately; indeed, the new ideas have not spread very widely even yet. The old idea was that the fluid electricity flowed through a wire very much as water flows through a pipe. But the new idea is that the energy does not flow through the wire at all. At every point along the wire enough energy passes into it to account for the amount of heating done, but the energy is transmitted by the ether outside the wire. If I am running this motor then the energy used in running it does not pass through the wire at all, but passes from the dynamo at the electric lighting station to the motor through the ether. The wire acts as the core of a disturbance in the ether

making the transfer of energy possible, but not itself transferring it.

But it is in another field of electric transfer that we have learned most about the real actions which go on, and a great part of our knowledge is due to three men—Faraday, Maxwell and Hertz. Faraday was the son of a blacksmith. In his youth, apprenticed to a printer, he read the proof of scientific books passing through the press, and finally so impressed Sir H. Davy that he gave him a position as an assistant at the Royal Institution, where he succeeded his benefactor as Professor of Natural Philosophy, and where he carried on those researches which made him famous. In his endeavors to unify the different phenomena of nature, he was led to look for some connection between magnetism and light, and he found that there was such a connection, the plane polarization of light being rotated in a magnetic field.

Maxwell, drawing his inspiration from Faraday, investigated the propagation of an electrical wave through space, and found that it followed the same laws as do light waves, and the velocity was the same as that of an electrical constant, which, on determination, proved to be that of light. So he advanced the hypothesis that light is really an electrical phenomenon. The proof of the hypothesis, however, rested on the fact that velocity of the electric disturbance was that of light, and that certain other electric constants bore the relation to optical constants that theory indicated. It remained for Hertz, a young German, scarcely thirty years old, to show by direct experiment that electrical waves are practically identical with those of light, and to put the electro-magnetic theory on a firm foundation. His method was to produce electrical waves of very short period, say $\frac{1}{100,000,000}$ of a second, and to directly investigate the method of their propagation. I have indicated on a large scale one way of experiment.

In the first place, if we have two tuning-forks of the same pitch and sound one of them, the other will sound sympathetically as it is called. Air waves are formed by the first fork, and these impinge on the second causing motions, slight

at first, but which are successively added, provided the forks are in tune, until the second fork sounds audibly. If the two are not in tune, the successive impulses are not added, but neutralize one another.

Now, is it possible to try a corresponding electrical experiment, and to do the same thing with electrical waves that we have done with air waves? In the first place, when I discharge this Leyden jar, the only thing we see is a flash of light. But if the energy of this charged jar is really stored up in the ether, then the ether is in a state of strain just as a stiff steel spring would be if it were fastened at one end and the other pulled aside. When we let go the spring, it will vibrate for a while, and in the same way when we let go the electrical strain by discharging the jar there will be an electrical vibration, and as the rate of vibration of the spring depends on its stiffness and weight, so the rate of electrical vibration of the jar depends on its capacity and the self-induction of the discharge circuit. That is, if the jar is smaller the time of vibration is less, and it is smaller for a short than for a great length of wire. So by having a very small capacity and short wire, Hertz has obtained 2×10^8 vibrations in a second; a number comparable with the vibrations of light.

Suppose we have a circuit of wire with a break in it, and suppose I set up vibrations in the circuit; then I have another circuit which also has a break in it, and I can increase the capacity and therefore change the time constant of either circuit by putting these jars in the circuits. Now, if waves are really sent off from the first circuit, and if the two are in tune, then I may get indications in the second. If I put the two circuits out of tune, there will be no indication in the second. You see the results. This experiment shows us that waves of electric energy are transmitted through the space between the circuits, and it is very imperfectly Hertz's method of experiment. With circuits so small that they could be easily carried about, he investigated the direction of the waves and their length. He found that they were reflected like light waves; that they were refractive and, in fact, that they were practically

identical. He directly measured the velocity, too, and found it to be, as nearly as he could measure, the same as that of light. In fact, the evidence is all but conclusive that light is an electro-magnetic phenomenon, and we know that light is transmitted by the ether, so we have at least one form of electric energy, which is transmitted by the ether.

Now, let us take up another form of transmission; namely, along a wire. Here we must try to label the energy coming from the dynamo and follow it to this lamp or motor. Poynting and Heavyside first proved mathematically that the energy appearing in the wire in the form of heat rains down on the wire from the space around it and the matter has an important practical bearing. Suppose I have a tube, open at both ends, immersed in a tank of water and suppose the length of the tube is great compared with its diameter. I can represent with it the old and the new idea of electric currents. If there is a piston in the tube and if I push the piston through, the water which represents the current will move steadily along the tube; the velocity of each point in its section is the same, it will move as fast near the outside as in the middle. If we move the piston back and forth rapidly, we will have a current alternating in direction, but the distribution of velocity will still be uniform. Now, suppose we remove the piston and simply move the tube in the water. If we move it slowly and in one direction, the friction of the sides will carry the water along with it, the current being represented by the rate at which the water passes a fixed point and the distribution is uniform. But if we move the tube rapidly back and forth through a short distance, the condition of the water in the tube will be different according as it is near the centre or near the outside of the tube. If the alternations are rapid and the amplitude is small, then the water near the centre may not move at all. In the first case, we have a current caused by a force acting along the wire; in the second, by a force all along the wire on the outside. The effect is the same for both in the case of a steady motion, corresponding to a steady current and the distribution is uniform across the section, as it is in the case of a steady current through a

wire. But in the case of the alternating forces the results are different; a force along the axis giving a uniform distribution, the force acting from along the outside giving a greater motion near the surface. Which of these corresponds with our experience in the case of alternating electric currents? The last does. With an alternating current along a wire if the period be very small a very little of the current reaches the centre.

Other experiments show the same thing almost conclusively; namely, that the energy of an electric current is conveyed by the ether around the wire. But if the wire does not convey the current, how does its presence affect the ether in its neighborhood? With our present knowledge of the properties of the ether it is impossible to say. We may represent the state of things, if we wish, as Lodge has done. He imagines that the ether is made up of a number of cog-wheels meshing into one another, and he further imagines that a conductor consists of wheels which have no teeth, but whose rims can slip over the cogs with a certain amount of friction, and so with a certain production of heat. If we had nothing but the cogs, we could not make them rotate for they would tend to turn each other in opposite directions and would stick fast. But with a number of wheels over which the cogged teeth could slide, rotation would be possible and we would have a condition of affairs representing a current.

If the wheels were elastic, then, if we try to turn one of them, there being no conductors around, the wheel would turn slightly, and this partial turning would be transmitted to the next, and so on; there being a definite strain through the whole space due to the stretching of these rubber wheels. And Lodge would represent the charging of a Leyden jar by this—the distention of the wheels representing the strain in the ether. We must then consider the charge of a Leyden jar as represented by a partial rotation transmitted through space with a velocity dependent on the elasticity of the wheels and their mass. When we discharge the jar, the wheels are relieved from their strain and oscillate for a while about their position of rest. If we

will consider for a moment, we will see that if there were such wheels half would revolve with, half against the hands of a watch, and this difference in the direction of rotation of the wheels may be taken as in some way representing the difference between positive and negative electricity.

And this model of the ether would in some way explain magnetism. The rotating cogged wheels represent magnetic effects, and if they rotate they must of necessity be included in a current. So we only have to adopt the old theory of Ampère, who supposed magnets were made up of a great number of small currents circulating around the molecules of the magnet and our model fits in with the facts of magnetism also. But no one—least of all Prof. Lodge—believe that this actually represents the mechanism of the ether. It helps us to have some definite notions, and no one has been more helpful than Prof. Lodge. But whatever the exact nature of the actions, there is not any doubt that some motion of rotation in the ether accompanies electrical and magnetic actions, and that electrostatic actions are caused by a strain in the ether.

We have taken up in an imperfect way three types of electric action, or rather four. Electrical waves, electrical strains or static electricity and electric currents, and in the latter we have included magnetic actions, especially if we accept Ampère's hypothesis. There is one thing we have not taken up, and that is the passage of an electric current through liquids. But this I will not take up.

So much for the transmission of electric energy; for its sources we can go in many directions. The largest, most important and cheapest source of electrical energy is the sun. The energy which makes up the organic life on the earth, the energy which causes the growth of every flower and plant and animal comes to us as electrical energy. Through many transformations, after long waiting sometimes, the electrician takes it again; transforms it a second time into electrical energy, and then distributes it for the uses of mankind.

THE METALLURGICAL ARTS AT THE PARIS EXHIBITION.

By F. LYNWOOD GARRISON,
Delegate of the INSTITUTE.

[*Continued from vol. cxxx, p. 51.*]

SAINT CHAMOND COMPANY.

This company, having a capital of 20,000,000 francs, was established at Rive-de-Gier in 1837 by MM. Petin and Gaudit, and afterwards at St. Chamond in 1850. The works are somewhat scattered in groups, the larger portion being between Lyons and St. Etienne, at Givors, Rive-de-Gier, Assailly and St. Chamond. The principal iron works are at St. Chamond, the mills and steel works at Assailly, the forges at Rive-de-Gier and the blast furnaces, with additional works, at Givors. At Boucau, in the southwestern corner of France, near Bayonne, the company have other blast furnaces and steel works; and in Corsica have blast furnaces at Torga, whence they derive excellent charcoal pig iron, which mainly constitutes the steel which makes their armor plates and castings famous. The company employs about 6,000 men, and its operations embrace almost all sorts of iron and steel objects, particularly ordnance, chrome steel projectiles, armor plates, etc.

The company's most important rail mill is at the Adour Works, where there are three large furnaces, two Bessemer converters and rail mills having a capacity of 70,000 tons per year; the ore used comes mostly from Bilbao and Bidassoa. At the same works iron railway sleepers are made in large quantities, wheels of all kinds and locomotives are manufactured at Rive-de-Gier, while the specialty of Assailly is the production of springs of crucible steel. At St. Chamond, ship and boiler plates are manufactured, and here, as at Rive-de-Gier, the heaviest forgings are made. Like the other great works in the Loire Basin, the St. Chamond Company possess special facilities for the manufacture of the highest

grade of war material. The steel ingots are made from the cast iron coming from the company's furnace at Givors and Boucau. Siemens-Martin furnaces are used, and the plant is claimed to be sufficiently large to produce 100-ton ingots.

The 100-ton hammer at these works was built in 1879, it was originally 80 tons, with a piston 75 inches in diameter,

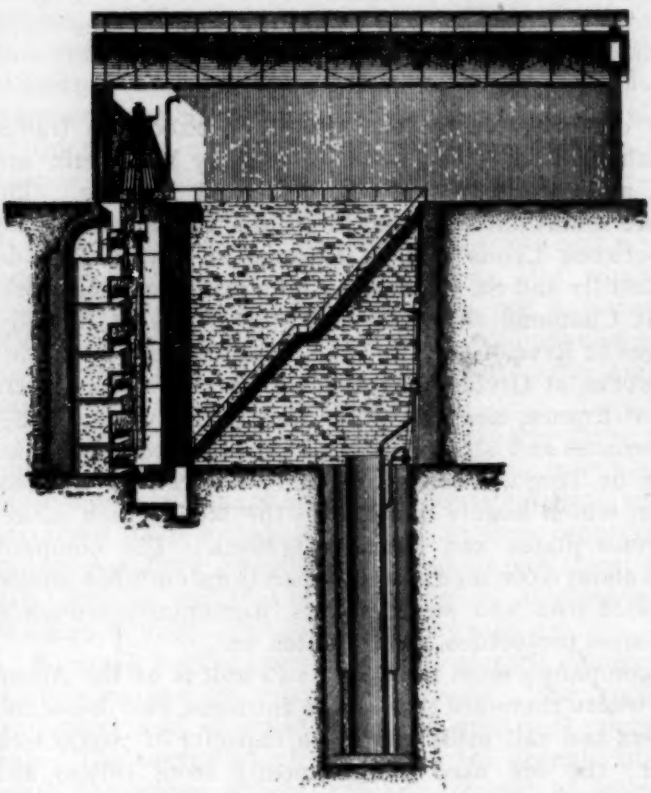


FIG. 8

15¾ feet stroke and an anvil of 800 tons, but the weight of the blow has since been increased to 100 tons. The cylinder is supported upon an A frame, the inclined standards being tied together by heavy horizontal bracing at the level of the guides. A similar arrangement was originally proposed for the new 100-ton hammer for Marrell Bros., at

Rive-de-Gier, but it has since been modified, and curved standards of the well-known Nasmyth pattern, with two horizontal bracings, substituted. The cranes attached to this hammer have a lifting capacity of 100 tons; they are worked by steam.

The tempering shop contains an upright heating furnace, sixty-five feet in length and a well of the same depth, containing the oil bath for tempering. *Fig. 8* shows a section of the same. The furnace is heated by means of six grates, ranged one above the other. The ingot or forging to be tempered is suspended in the furnace by means of a chain from a fifty-ton travelling crane; during the heating it is turned slowly round, and from time to time shifted through a small vertical distance, with the object of securing as nearly uniform heating as possible. When sufficiently heated, the ingot or forging is carried along the pit and lowered into the oil tank, which is about ten feet in diameter, the top nearly flush with the floor of the pit. The lifting and travelling gearing of the crane is worked by steam, but the lowering is effected by some hydraulic means in order to insure a descent and immersion in the shortest possible space of time.

The St. Chamond Company claim to have been the first works in Europe to produce armor plate. It seems most of their productions of this kind are iron and compound plates, solid steel plates not having, as yet, received much attention. The iron plates are made by PILING small bars of a V or W section; the plates thus produced are again piled and rolled. Most of the plates made here are compound, the iron plates made in the manner just indicated serving as a foundation for the steel covering which is welded to them. The heaviest compound plates produced in this manner weigh about forty tons.

For ordnance the ingot to be forged must have a section at least four times larger than the forging when ready to be turned. The weight of the piece after forging is never more than fifty per cent. of that of the ingot used. Before tempering, the steel must have a tensile strength of from twenty-five to thirty-eight tons per square inch, with a maximum

extension of eighteen per cent. After tempering, this is increased to from thirty-four to fifty tons, with from twelve to fourteen per cent. elongation. Most of the steel used for armor plate and ordnance is made in open-hearth furnaces, some with basic and others with acid linings. I believe, however, that the basic linings have given so much satisfaction that they are now used almost exclusively. Bricks of Styrian magnesite are used for the purpose. The magnesite from this locality is found preferable to the purer mineral from the Island of Eubea, as it is slightly ferruginous.

In casting large ingots from the open-hearth furnaces, the casting is frequently begun before the entire charge is received in the ladle, in order to cast as hot as possible.

For cutting armor plate to the finished size circulars saws are used at St. Chamond. They are discs six and one-half feet in diameter, having sockets for receiving the cutting tools, which are arranged in pairs, the first taking out the centre and the second trimming the sides of the cut, which is about an inch broad. The most minute care is required in adjusting the tool, the fitter being provided with a great variety of packing pieces of varying thickness down to strips of paper. These saws will, it is claimed, cut a fourteen-inch plate at the rate of about an inch per hour.

The exhibit of the St. Chamond Company was one of the very best of the works in the Basin of the Loire. Perhaps the most striking object in it was a fac-simile of a 100-ton steel ingot such as are made at these works. These ingots are usually made into gun forgings of the largest size. Very fine specimens of armor plate were also shown; one compound plate weighing over twenty-seven tons forming the top of a turret, with two embrasures worked in the plate for six-inch guns. Plates of this kind are shaped under hydraulic presses, then the embrasures worked out under the hammer. A few iron and steel plates of exceptional size were exhibited as specimens of what work can be done at the company's rolling mills. One of these was of iron, 32 feet long, 9 feet wide and 0·63 inches thick; another of steel, 46 feet long, 6 feet wide and 0·63 inch thick. Two other

plates of soft steel remarkable for their extreme thinness; one was 19 feet long, 39⅜ inches wide, and 0·08 inch thick.

A crank-shaft for a marine engine weighing fourteen tons was exhibited; it was one of the first of such large dimensions made in one piece. The largest gun forging exhibited was a tube for a 13·39-inch gun, 36 feet long, weighing 14 tons; this tube was bored, tempered and turned to within 0·08 inch of its final size.

The following are the tests of this steel after tempering: Breaking load, 41·90 tons; elastic limit, 22·86 tons; and extension, 15 per cent. Another specimen for a 5·51-inch gun weighing two tons was tempered in water, the results shown greater hardness and less elasticity; they were at the breech, breaking load, 50·79 tons; elastic limit, 29·21 tons; and extension 12 per cent.; at the chase 53·97 tons, 31·75 tons, and 10 per cent., respectively.

Perhaps the most interesting gun forging in the exhibit was one for a 14·57-inch gun *forged on a mandrel* under a steam hammer. This method of forging seems to have been introduced by the St. Chamond Company in 1888.

In a show-case were exhibited a series of fractured specimens of steel used for various purposes. The following table gives a general idea of the characteristics of each: *

	Carbon.	*Silicon.*	*Manganese.*	*Sulphur.*	*Phosphorus.*	*Ultimate Strength.*	*Elastic Limit.*	*Elongation.*
						tons per sq. in.	*tons per sq. in.*	*per cent.*
(1) Sample of steel for car tires (Paris, Lyons and Mediterranean R. R.), ...	·30	·15	·50	·018	·02	31·75	15·87	22·
(2) Steel for locomotive tires (Paris, Lyons and Mediterranean R. R.), ...	·40	·15	·60	·012	·02	38·09	20·83	22·
(3) Steel for special quality of tires, ...	·35	·16	·55	·010	·005	44·44	25·40	18·
(4) Steel for naval guns, ...	·48	·21	·55	·007	·009	41·27	22·86	20·
(5) Steel for axles, ...	—	—	—	—	—	29·21	15·24	25·
(6) Chrome steel for tires, . . .	—	—	—	—	—	50·79	30·48	13·5
(7) Steel for tires (tempered and reheated), ...	—	—	—	—	—	43·17	—	16·
(8) Same as No. 2, ...	—	—	—	—	—	38·09	24·73	20·
(9) Special steel for locomotive tires, ...	—	—	—	—	—	44·44	24·76	15·

* I have copied this table from *London Engineering*, September 20, 1889, p. 347.—F. L. G.

Amongst the railway material in this exhibit was an interesting series of steel tires:

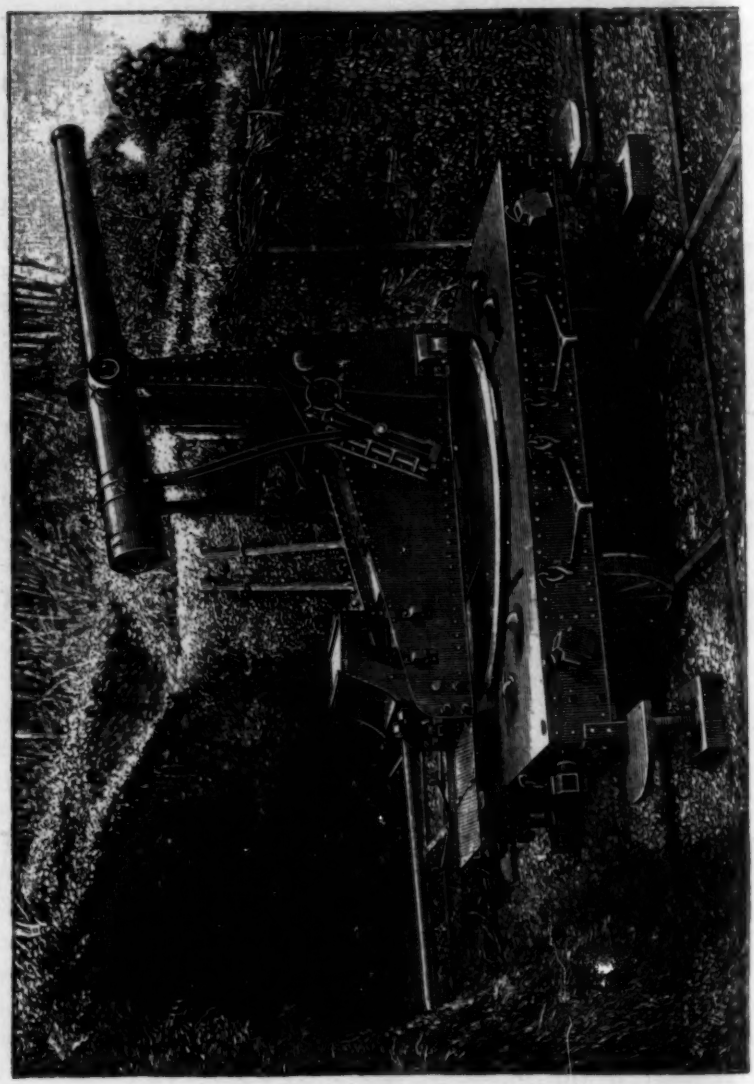


FIG. 9. Siege Gun, with Barbette Carriage and Revolving Platform.

(1) 54·33 inches in interior diameter, 5·62 inches wide, and 3·66 inches thick; it withstood the regulation test of four

blows from a 2,200 pounds weight falling through a height of 8 feet 9 inches, and afterward twenty-three blows from the same weight falling from a height of 32 feet 9 inches. The tensile strength was 41·65 tons per square inch, elongation, 21·5 per cent. (2) 32·29 inches in internal diameter, 5·19 inches wide, and 2·44 inches thick; withstood three blows of same weight falling same distance, and seven blows falling from a height 32 feet 9 inches; tensile strength 32·51 tons, elongation 27·5 per cent. As an example of the work which can be executed by this company, an iron ring was shown, 6 feet 7·76 inches in diameter, 14·37 inches wide, 3·82 inches thick, and weighing 3,968 pounds.

FIG. 10. Siege Gun, with Barbette Carriage and Revolving Platform.

The St. Chamond Company's exhibit of war material may, for convenience, be divided under six heads: projectiles, armor plates, small arms, gun carriages, heavy ordnance and turrets. A series of three shells were shown, illustrating a method of manufacture peculiar to the company; they are forged hollow out of a block and shaped in a hydraulic press, the rear of the shell being closed solid by the same means. Some of the projectiles shown had been subjected to severe tests with but little deformation and damage. The largest of them, a shot 16·54 inches in diameter, had

FIG. 9. Siege Gun, with Barbette Carriage and Revolving Platform.

penetrated a plate 19·69 inches thick, the angle of firing being 20°. Another, 13·39 inches in diameter, passed through a steel plate 15·75 inches thick, the angle of fire being normal.

The armor plates were equally interesting, the largest, a compound plate, weighing nearly fifteen tons, and from twelve to thirteen inches thick, had received three shots, which penetrated to depths of 5·82, 4·52 and 5·31 inches. The next plate was somewhat larger, but not so thick, being 4·72 inches and weighing seven and a half tons.

The St. Chamond Company claim that the iron armor plates manufactured by them will resist, without any serious deterioration, a great number of rounds fired at the same spot; it being understood, of course, that the thickness of the plate is proportioned to the energy of the shot fired against it.

Amongst the exhibit of small arms, was a rapid-fire gun on the Daudeteau system, 1·85-inch bore and 45 calibres in length. The breech mechanism of this gun is an interrupted screw and not a wedge, the opening and closing action being very simple. The weight of the projectile is about three pounds, and the initial velocity 2,000 feet per second. Several 3·15-inch mountain guns were shown, the weight of each complete was 273 pounds. These guns are said to throw a twelve-pound shot with a muzzle velocity of 1,000 feet. This type of gun is made in two sections, which are screwed together and a tight joint maintained by a tight metallic ring; the breech action is on the De Bange system. The carriage is divided into four parts: the body, the framing carrying the axle and trunnions, the hydraulic brake, and the two wheels. The maximum weight of any separate part does not exceed 140 pounds. A regulation 3·15-inch field gun was also exhibited. This gun gives a muzzle velocity of 1,600 feet. The total weight of gun and carriage complete is one and a half tons.

Two samples of siege artillery were exhibited. A barbette carriage, mounted on a revolving platform (*Figs. 9* and *10*). This type of carriage is used for guns of from 4·72 inches to 5·30 inches bore. It will be observed that the

gun is mounted at the upper end of a frame, which can be turned around a horizontal axis secured to the main carriage, which is mounted on a platform, free to turn round a central vertical pivot. The recoil causes the gun to fall about forty inches. A rifled mortar of the light 6·10-inch type, 5 calibres in length, fitted with the De Bange breech was also exhibited. This gun fires a ninety-pound projectile with a muzzle velocity of 650 feet, the angle of fire varying from 5° to 60°.

Heavy coast and naval guns were exhibited, partly in models and partly in actual objects. They include a model of a 10·82-inch (275 millimetres) coast gun *Fig. 11*, a naval

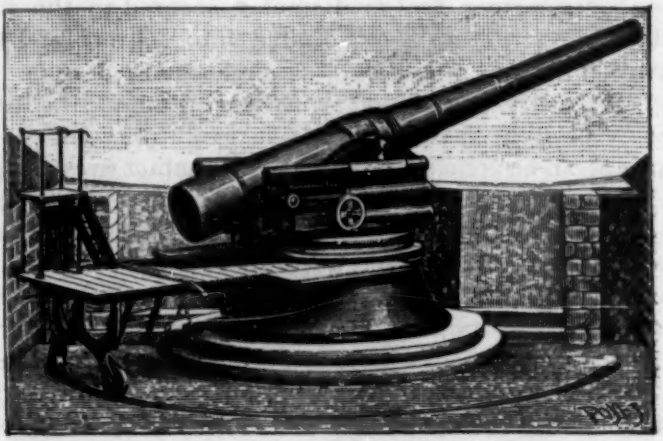


FIG. 11. Twenty-seven-and-one-half-centimetre Coast Gun.

7·87-inch (200 millimetres) gun *Fig. 12* (shown in firing position), and a naval 6·10-inch (175 millimetres) gun, all mounted on a forward pivoted naval carriage.

By far the most interesting part of the St. Chamond Company's exhibit of war material were the models of the Mougin armored turrets. The one shown in *Figs. 13–17* is 19 feet 8 inches in internal diameter, the roof protected by 9·45-inch domed plates of armor, and arranged to receive two 5·90-inch guns.* The outer and lower part of the turret

* The construction shown in *Fig. 17* differs slightly from the others.

is made in segments of hard cast iron about a foot thick; the inner and moving part of the turret consists of an iron frame-work, on which are carried the guns, carriages, and armor plates protecting them. This structure rests on twelve vertical wheels, and is guided by ten horizontal centring wheels. Most of the weight, however, is carried upon a hydraulic piston, so that the wheels have but little load to support. A winch in the masonry base of the structure serves to turn the turret; a complete revolution can be made in one minute. Smaller winches are placed near the guns to raise the ammunition. The guns are fired automatically by a very ingenious arrangement. A large brass ring about fourteen feet in diameter, secured to the inner walls of the structure, is graduated into degrees and minutes; pointers are placed at the angle marked upon this ring, at which it is intended that the gun should be fired; they are brought in contact at each revolution with the terminals of an electric battery, and this contact fires the gun the instant its axis enters the angle desired. An interesting design for an oscillating two-gun turret was also shown. The turret is hung upon horizontal trunnions, and the required oscillation obtained by hand after the guns have been loaded and trained; after firing, the turret is returned to the ellipse position, which, it is claimed, can be done in five seconds. The movement of the turret is effected by a drum fixed to the movable portion and by two cables coiled round it in opposite directions, the ends of which are attached one to the drum and the other to a fixed part of the turret; two or three men are sufficient to move the structure, thus rendering any other means of power unnecessary. The ends of the guns not projecting beyond the turret, and the embrasures being very small, the structure is obviously well protected from hostile fire. The guns are not mounted on carriages; the trunnions, which are movable between the two sides of the curved slides, describe, when the gun is being trained, the arc of a circle whose centre is near the muzzle of the gun; the latter being balanced, this movement, which ranges from 1° to 25°, is obtained without any difficulty. The principal operations in this type of

turret, such as training the guns, turning the turret and maintaining the supply of ammunition, is much the same as already described, except the whole work is done by five men and one officer.

The St. Chamond Company exhibited a model in relief illustrating the remarkable system of fortification advocated by Mougin. The chief feature of the system consists of a huge monolith of concrete, in which are constructed the various chambers of the fort and the foundations of the turrets by which it is defended (*Fig. 18*). The details are

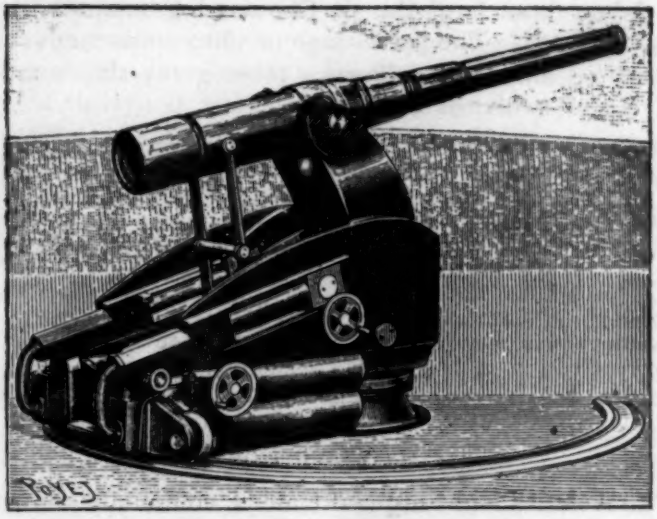


FIG. 12. Twenty-centimetre Naval Gun.

shown better in *Fig. 19*. There are eleven turrets in all, one eclipse turret, containing two six-inch guns; two turrets for all around fire, armed with similar guns; four eclipse turrets for rapid-fire guns, and four eclipse observatory turrets. The middle of the fort is protected by ten feet of concrete, under which is what might be considered as the barracks, the stores and magazines, which would thus be concentrated and could always be under the personal supervision of the commander; the strength of the garrison does not exceed fifty or sixty men. Access is obtained

to the fort by means of a covered way about 70 to 100 feet in length, and a well with stair-case 60 to 70 feet in depth. The top of the stair-case is enclosed in a cylinder carried on a rod having a rise and fall of about six feet. The top of the cylinder is protected by armor plate. When the piston-rod is raised, access to the stair-case is obtained; when the cylinder is lowered, the armor plate at the top protects the entrance from hostile fire. "This system of defence has been very carefully worked out in all its details, both from a military and sanitary point of view."*

A series of interesting samples of ferro-chrome made at the Adour branch of the St. Chamond Company's works were exhibited. The percentage of chromium ranges from 44·30 to 65·20. The following table gives the complete analyses of twelve of the samples:

	1	2	3	4	5	6	7	8	9	10	11	12
Chromium, . . .	62·70	64·80	62·39	64·00	44·30	57·00	64·50	63·00	51·10	55·90	65·15	65·20
Iron, ...	23·00	21·80	28·10	23·40	45·00	30·95	24·00	25·38	39·10	34.20	22·00	21·90
Manganese, . . .	0·43	0·43	0·45	0·52	0·80	0·56	0·20	0·42	0·40	—	0·52	0·38
Carbon, ...	11·25	12·00	9·55	11·10	8·30	9·38	11·50	10·03	6·75	9·10	10·32	11.80
Phosphorus, . . .	0·06	0.06	0.06	0·06	0·06	0·06	0·06	0.06	—	0·06	0.06	0·06
Silicon, ...	—	0·50	0·60	0·49	1·40	0·43	0·40	0·40	0·32	0·56	0·53	0·38

UNIEUX STEEL WORKS.

The Acieries and Forges d'Unieux, commonly known as Jacob Holtzer & Company's Works, were founded on the Loire, in 1829, by Jacob Holtzer, and since his death have remained in the family. In the beginning the establishment was on a very limited scale, and the output was confined to high grades of steel for tools, springs, etc. The works were gradually enlarged, and it was here that the first puddled-steel furnaces in France were constructed.

The works now employ 1,000 men, and consume about 40,000 tons of fuel per year. Much of the pig iron used by the company is made in their charcoal furnaces at Ria

* *Engineering*, October 4, 1889. p. 403.

(Pyrénées-Orientales); they also use ore from Thorrent, Sahorre and Escaro. In the manufacture of cutting tools only the best quality of Swedish charcoal pig is used. The works contain seven Siemens gas crucible furnaces, each holding thirty sixty-pound crucibles, so that ingots from five to six tons can be cast; the total daily production ranges from thirty to thirty-five tons. The pots are somewhat thicker than those used in coke furnaces; ordinarily, they will last longer than when coke is used for fuel, as the gas does not cut them like the coke ash. From six to ten heats is the usual run. There are ten reheating furnaces in different parts of the works, for the rolling mills and steam-hammers. There are twelve cementation furnaces (one-half the total number in France in 1887), for the production of blister steel, six thirty-ton and six fifteen-ton capacity; 2,500 tons of blister steel are produced by these furnaces annually. The new portion of the works contains a 2,000-ton hydraulic forging press, made by Messrs. Davy Bros., of Sheffield; the same building contains one fifty-five-ton and one fifteen-ton travelling crane.

The annual production of the works, prior to the extensions which have just gone into operation, is about 4,000 tons of crucible steel, used mostly for tools and other similar purposes. This company has long been celebrated for their chrome steels, of which three grades of hardness are produced. They were the first works in Europe that produced chrome steel. The tungsten (wolfram) steel, for which they are equally celebrated, they claim does not require tempering. Messrs. Holtzer & Co. make a specialty of cast-steel rifle barrels, which they are now producing at the rate of 45,000 per month, for the Lebel rifle. About 500 tons of special castings for machinery, 300 tubes for heavy guns, and 200 tons of chrome-steel plates, are produced annually.

In 1882, the Holtzer Company commenced the manufacture of chrome-steel projectiles.

The first trials were made in July, 1882, with a 13·4-inch projectile, which was fired against a 15·75-inch iron plate at an angle of 18°; three such projectiles passed through

the plate and backing, one of them remaining uninjured. In 1884, the French Marine Department carried out a series of trials with 13·4-inch projectiles, supplied by various makers, the targets being steel plates made at Creusot, and compound plates sent from Sheffield; the Holtzer projectiles passed through both types of plates, 15·75 inches in thickness, without breaking up, a result that again surpassed all previous results, and decided the adoption on a large scale of this class of shot. Since that date, iron armor plates have been entirely abandoned for testing purposes in France in favor of the solid steel plates. At the Exhibition, a remarkable example of these projectiles is shown; it is a

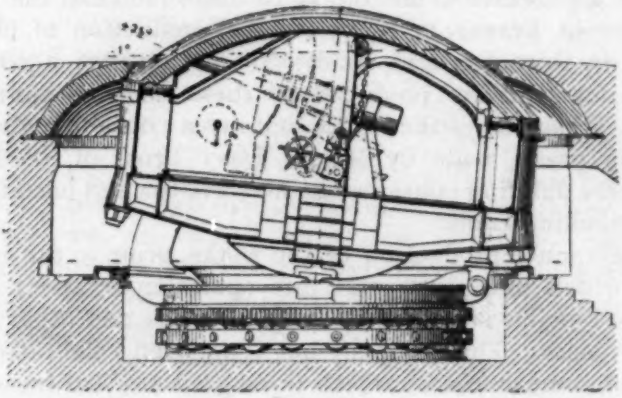


FIG. 13.

10·63-inch shot, upon the firing of which depended the acceptance of a lot of 275, last April; this shell passed through a steel plate 9·84 inches in thickness, made at Creusot, and was picked up 300 yards beyond the plate in a perfect condition, its length having been reduced ·08 inch, its diameter enlarged ·024 inch, and its axis twisted ·08 inch. Some years after these trials had resulted in the adoption of chrome-steel projectiles in France, the English Admiralty became interested in the subject, and since that date has been among the regular customers of Holtzer & Co.

Perhaps the most interesting exhibit of the Holtzer Company at the Exhibition was a series of projectiles of various calibres, which have been fired through armor plates of

different thicknesses, placed side by side with similar projectiles which have not been fired at all. Excepting for a few scratches at the apex and on the sides, the projectiles which have been fired through the plates show little deterioration.

The following description of "*ferro-chrome*" and chrome steel, by M. Brustlein, of Holtzer & Co.'s, will be found interesting in this connection:*

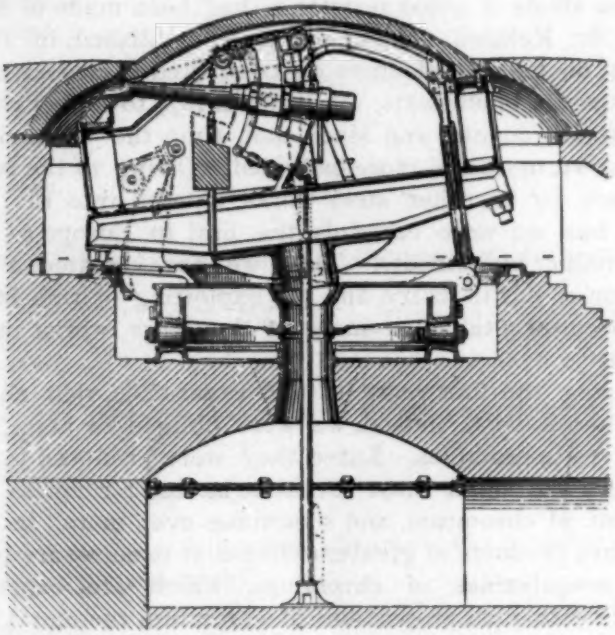


FIG. 14.

Alloys of iron and chromium, containing more or less carbon, have long been known as laboratory products. Berthier makes mention of chrome steels in his memoir published in 1820, and laid stress on the method of making ferro-chrome, predicting that it would be used to introduce chromium in cast steel.

* Paper read before the International Congress of Mines and Metallurgy, held in Paris, September, 1889.

Later, Boussingault devoted some attention to this subject, and especially showed the presence of three to four per cent. of chromium in the castings made prior to 1867 in the neighborhood of Medellin, in the Province of Antioquia, South America.

It was in the United States that these steels were first produced to any extent for industrial purposes. In 1875, on beginning my tests at the Holtzer works, I had read that chrome steels of great resistance had been made in Brooklyn. Mr. Rolland, mining engineer, published, in 1878, a report on its manufacture as conducted in Brooklyn. In consequence of our tests, we began in 1877 to deliver chrome steel to our clients, and since that time the consumption has grown more and more extended. Owing to the results obtained by us, other steel works entered into the same field; but we were certainly the first in Europe to make this product industrially. Thus we have created a new division of our industry, and the exploiting of this branch has been profitable to most of the large works in our territory.

During the first years of our experience, rich chrome iron did not exist; indeed, we were obliged to make them ourselves in crucibles. Later, they were produced in high furnaces and small blast furnaces, having a richness of 60 per cent. of chromium, and sometimes even more. In order to obtain products of greater richness, it is necessary to use pure sesquioxides of chromium, which are expensive, besides with such proportions of chromium the metal fuses with too great difficulty to be treated in industrial work.

We have collected a series of samples of chromes and ferro-chromes, of which we give herewith the description:

Sample bar No. 2, obtained by reducing sesquioxide of chromium, without excess of carbon in a magnesia crucible.

	Per Cent.
Chromium,	84
Carbon,	9

The bar contains holes, the presence of carbon tending to show that the reduction had not been completed.

Sample bar No. 6, obtained by reducing sesquioxide of chromium in a graphite crucible.

	Per Cent.
Chromium,	82
Carbon,	7·5
Silicon,	8·2

Sample bar No. 1, obtained by reducing sesquioxide of chromium in a brasqued crucible.

	Per Cent.
Chromium,	80
Carbon,	11

Sample bar No. 3, of rich ferro-chrome, containing very little carbon.

	Per Cent.
Chromium,	71·5
Carbon,	3·46
Iron,	20–25

No. 4.—Ferro-chrome, cast in the crucible furnace of the works.

	Per Cent.
Chromium,	60
Carbon,	8·6

No. 5.—Ferro-chrome, poured in chill for ordinary use.

	Per Cent.
Chromium,	50
Carbon,	8

Nos. 7 and 8.—Silico-ferro-chrome. No. 7 cooled slowly and No. 8 poured in chill.

	Per Cent.
Chromium,	30
Silicon,	8
Carbon,	5

No. 9.—Poured in chill.

	Per Cent.
Chromium,	42
Carbon,	7·3
Silicon,	2·1
Manganese,	0·4

This specimen serves to show the special shiny fracture of the metal.

Nos. 10 and 11.—These two specimens have the same richness in chromium, but differ in the contents of carbon.

No. 10—

	Per Cent.
Chromium,	30
Carbon, to saturation.	

No. 11—

	Per Cent.
Chromium,	30
Carbon,	4·7

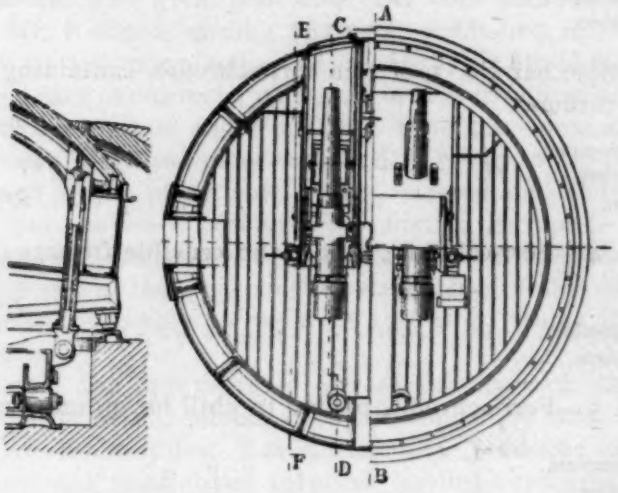


FIG. 15.

Nos. 12 and 13 do not differ, except that No. 12 cooled slowly, and that No. 13 was poured in chill.

	Per Cent.
Chromium,	25
Carbon,	30

In No. 12, white needles are detached in a very apparent fashion on a gray casting. I estimate that there is not enough carbon to saturate all of the mass and that the white needles are formed at first and more carbonized than in the cast.

Nos. 14, 15 and 16.—These three numbers have the same contents of chromium, fifteen to sixteen per cent., but No. 14 is saturated with carbon, while Nos. 15 and 16 do not contain more than two to three per cent. No. 15 is cooled slowly, and No. 16 is poured in chill.

Nos. 17, 18, 19 and 20.—These four numbers have the same contents of chromium; that is, twelve per cent. No. 17 is saturated with carbon, while the three following numbers only contain two per cent. No. 18 is cooled slowly, while No. 19 is poured in chill, and No. 20 is the same as No. 19 drawn out in bars. This shows that a metal with twelve per cent. of chromium and two per cent. of carbon may be

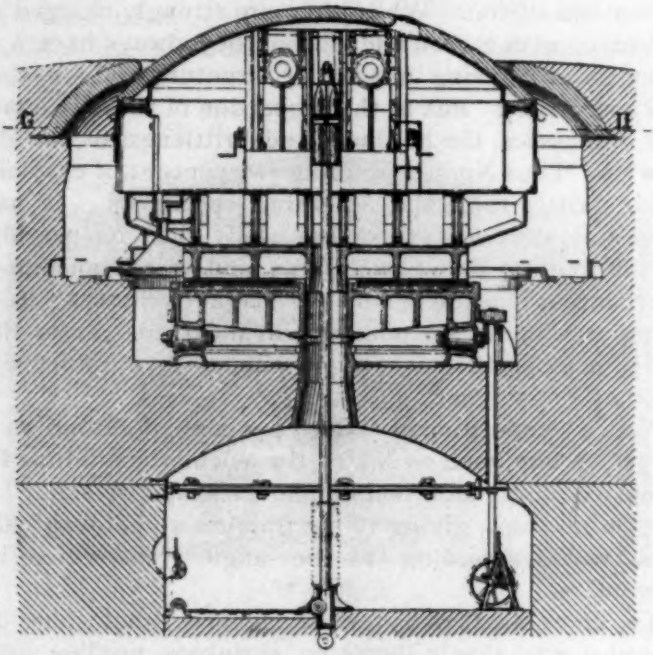


FIG. 16.

forged if one operates with precaution and is found on the line of separation between the steel and the casting.

Nos. 21, 22 and 23.—These three samples all contain about seven per cent. of chromium. No. 22 only contains 1·25 per cent. of carbon. Nos. 21 and 23 have the following composition:

	No. 21.	*No. 23.*
Chromium, about,	7·	7·
Carbon,	5·	4·5
Silicon,	0·4	0·25
Manganese,	0·38	0·36

From the foregoing, it appears that the chromes and the ferro-chromes may be combined with large proportions of carbon, much greater than those that are found in ferro-manganese. The appearance of the fracture of ferro-chromes differs more according to their contents of carbon and silicon than with their contents of chromium. Also, it is very difficult to determine at sight the proportion of chromium of a ferro-chrome saturated with carbon or with carbon and silicon. When they are strongly charged with carbon, or with carbon and silicon, they always have a tendency toward having an acicular structure, and are always hard and brittle. But as the proportion of these two metalloids diminishes, the hardness and brittleness of the alloys grow less. Thus No. 3, containing 71·5 per cent. of chromium, is less brittle than the adjoining specimens. It has a bluish tint, scratches glass more easily than its neighbors, and the fracture shows small faces, and is not acicular. It is very strongly attracted by the magnet, whereas, the preceding specimens are not sensibly affected. It is, therefore, principally the carbon and silicon that influence the action of the magnet.

With a composition of sixteen per cent. of chromium and of 2·7 of carbon, such as No. 15, the acicular crystalline form is replaced by small rectangular cleavage or small faces arranged in steps, giving to the fracture a chatoyant effect, which varies according to the angle from which it is examined.

We know that rich ferro-manganese that has been allowed to cool slowly shows on shrinkage needles similar to those of ferro-chrome; and in manganese castings it is not until their contents in manganese fall below ten per cent. that these large specular faces appear, which have been given the name of spiegel. It would be of interest to ascertain whether poor ferro-chrome which is saturated with carbon would possess this peculiarity of imparting to its fracture these large specular faces.

It was especially for this purpose that in preparing samples I made those containing so small a proportion of chromium.

Thus No. 21 shows no such faces, while in No. 23 the peculiar crystallization of spiegel, but of spiegel with faces slightly straited, is very greatly developed. These two samples only differ by the proportion of carbon and silicon that they contain; therefore we are tempted to attribute to the influence of silicon the absence of faces in No. 21. Nevertheless, it will require a great number of trials in order to draw a conclusion.

Besides, the question appears to be of interest from the following point of view:

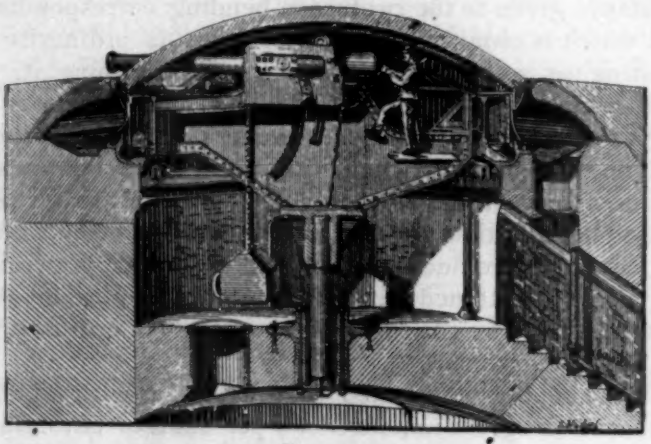


FIG. 17.

Steel only differs from cast iron by a small proportion of bodies foreign to iron; hence, it is natural that these bodies should possess in themselves certain properties which they impart to steel having an analogous relation to those which they give to cast iron.

Thus we see that manganese united to carbon produces in cast iron those enormous cleavages which distinguish the spiegel and remove all solidity from the metal; and hence we should fear that, in a carbonized steel, the manganese favoring the crystalline development would injure, for that reason, the solidity of the metal, which, in reality, does take place. The same observation applies to silicon, but in an inverse sense; that is to say, by preventing the

crystalline development. For ferro-chromes, the tendency of chromium to give the specular aspect to cast iron is slight—in any case, less than in the manganese—which makes it possible to prevent this metal from having the same objectionable features that the manganese does.

Experience goes to prove this condition of affairs. There may be introduced varying proportions of chromium of which the effect is to increase the resistance of steel without diminishing the tenacity corresponding to its carbon contents, and even, it appears, to slightly increase that tenacity. In consequence, it is possible to obtain, with a resistance given to the rupture, a bending corresponding to that which is obtained with a steel that is ordinarily less resisting or softer; that is to say, in describing it, as a metal which, well handled, offers a very great security.

At the forge, an ingot of chrome steel may be worked with no more difficulty than with ordinary steel of the same hardness; nevertheless, when hot, it offers a greater resistance to deformation. When an ingot is cut hot by a cutter, the metal is more ductile; the point of contact between the two pieces is flattened out into a thin web before breaking. It is influenced by the fire even less than an ordinary steel of the same hardness.

In the cold, when worked on a lathe or with a plane, a steel containing, for instance, two per cent. of chromium is always a little harder to cut than ordinary steel; nevertheless, if it is properly reheated the difference is not great. Steel that contains less chromium, even when it has one per cent. carbon, may be worked without difficulty on a lathe. Tempered with oil or with water, the temper penetrates more deeply than in a carbonized steel of the same degree of carbonization without chromium.

The particulars which present themselves during the heating and cooling, during the passage of carbon from the combined state to the dissolved state, have been studied by M. Osmond, who compared it with other steels in his interesting researches on this subject.

To continue, chrome steels offer a resistance to shock and to fracture which for the time being have the prefer-

ence for a certain number of uses. On the other hand, when once made into ingots, it can be manipulated like ordinary steel, which is an additional advantage. But they offer in their manufacture difficulties of a special nature. In a state of fusion which takes place at high temperatures, the chromium which it contains has a tendency to take up oxygen from the air. For in such case there is not formed, as is the case with oxide of manganese, a liquid and fusible silicate lighter than steel, which comes rapidly to the surface. It would be supposed that there would be a tendency to form a chromite of iron; in any case, chromium, in burning, causes in its immediate neighborhood the decarbonization of the steel and the oxidation of the iron, giving rise to a creamy layer, of which the little fragments rest readily not only on the edges of casting pot, but even in the mass of the metal. This effect is heightened when the contents of chromium is greater, and when the steel itself is poorer in carbon. The portions thus oxidized will not unite under any working, no matter to what temperature they may be heated.

For the same reason, the layer of oxide which is formed on heating the ingots or bars is stronger and adheres closer than in ordinary steel, and does not easily dissolve in borax. Also, chrome steels only unite with difficulty or not at all, according to amount of chromium they contain. Hence, it is assumed that a metal containing much chromium is undesirable for puddling. As a matter of fact, every lump of refined metal that is made becomes surrounded with an oxidized pellicle, which adheres to it and is, in consequence, insoluble, so that under a shingling hammer it is impossible to collect these lumps in a proper and coherent mass.

Although we have not tried it, we are persuaded that every attempt at puddling will encounter the difficulty that we have described. Ferro-chromes are, as a usual thing, very strongly carbonized, and hence it seems natural to consider their use in place of ferro-manganese for the purpose of recarbonizing steel at the close of either a Bessemer or Martin operation. It will be necessary in this case to keep

account of the difficulties which will be the consequence of the properties which we have described.

FIG. 18. Mougin Turret Fort, showing Foundations.

We regard it as very difficult to produce an extra soft steel containing much chromium, for instance, a metal that

when cast will contain from one to two per cent. of chromium, and one or two thousandths of carbon. Judging

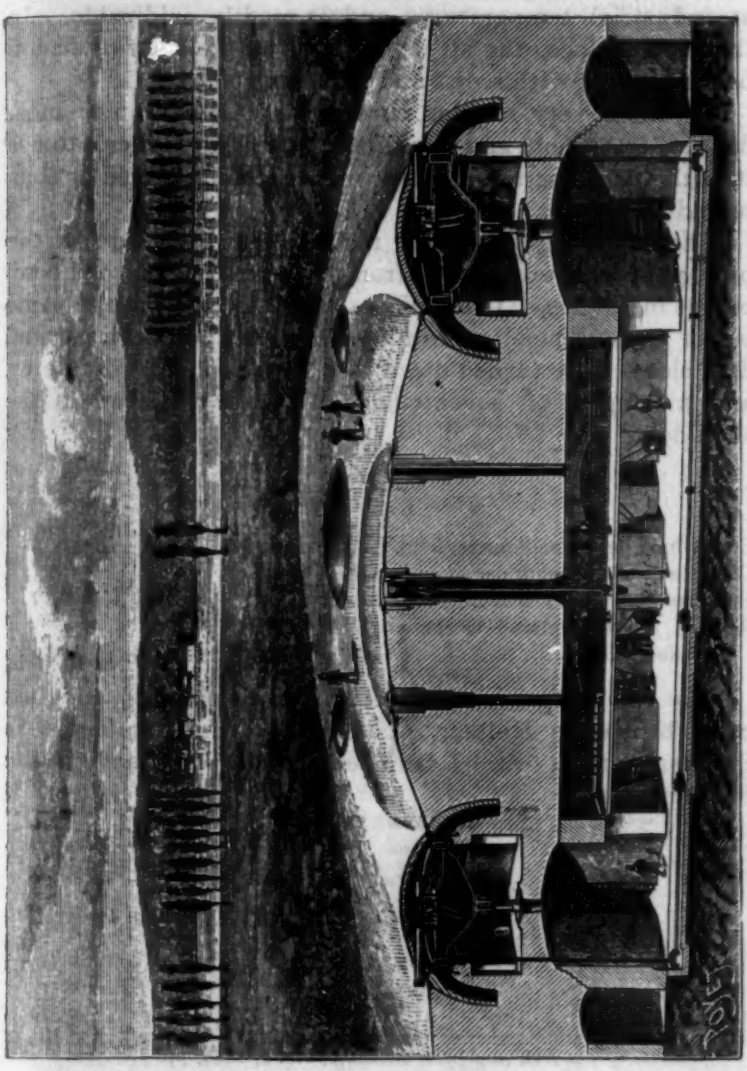


Fig. 19. Mougin Turret Fort, showing Details.

by analogy, a metal of this composition, if it is clear and sound, will have a remarkable ductility.

Fig. 18. Mougin Turret Fort, showing Foundations.

There is with this production a double difficulty. First, the ferro-chrome which is made is always very rich in carbon, and an alloy but little carbonized is no longer fusible at industrial temperatures and is readily oxidizable. In the second place, the steel obtained at the state of fusion becomes filled with scoria and veins on cooling.

For these very reasons, chrome steel will require most delicate treatment, and it will be exceedingly difficult to use it in the manufacture of sheeting, especially mixed or compound sheeting.

The following tests were made a few years ago in the presence of representatives from the principal railroad companies in France. Three pieces were taken from the same bar of chrome steel containing about 0·7 per cent. carbon. The pieces were turned down to nine millimetres diameter, and a length of seventy-five millimetres between the shoulders.*

	No. 1. Annealed.	*No 2. Annealed.*	*No. 3. Tempered in Oil and Annealed Dark Red.*
	kilogs.	*kilogs.*	*kilogs.*
Elastic limit per sq. millimetre, ...	40·2	43·3	140·
Ultimate tensile strength per sq. millimetre,	73·0	70·8	150·
Elongation per cent., ...	17·9	21·2	6·2
Relation of the ruptured to the original section, ...	0·308	0·333	0·708

The following series of steels were exhibited in glass cases by Messrs. Holtzer, each classified and marked with the result of the test. I believe the tests were made at the Holtzer works.

CHROME STEEL.

No. of Test.	*Elastic Limit per Sq. Mm.†*	*Tensile Strength per Sq. Mm.†*	*Elongation.*	*Relations of Ruptured to Original Section.*
	kilogs.†	*kilogs.†*	*per cent.*	
1, ...	—	110·3	9·5	0·455
2, ...	44·7	73·5	19·5	0·37
3, ...	10·7	133.6	8·0	0·57
4, ...	45·4	76·8	18·3	0·410

* *Journal of the Iron and Steel Institute*, No. 2, 1886, pp. 770–778.

† Kilograms, one of which equals 2·2 pounds. One square millimetre equals $\frac{1}{645}$ of a square inch. Thus by multiplying the number of kilograms given by 2·2 and then by 645 we get the number of pounds per square inch.

CHROME STEEL.—*Continued.*

No. of Test.	*Elastic Limit per Sq. Mm.* — *kilogs.*	*Tensile Strength per Sq. Mm.* — *kilogs.*	*Elongation.* — *per cent.*	*Relations of Ruptured to Original Section.*
5,	83·5	95·7	13·0	0·419
6,	—	137·4	6·0	0·695
7,	39·2	65·7	22·5	0·615
8,	76·8	87·6	6·0	0·825
9,	—	149·6	0·5	1·00
10,	39·2	66·4	26·5	0·495
11,	74·8	86·2	12·2	0·70
12,	112·2	121·6	6·5	0·74
	CHROME AND TUNGSTEN STEEL.			
1.	39·9	67·0	20·8	0·70
2	73·5	82·1	7·0	0·67
3	133·6	143·5	2·5	0·94
4.	46·0	72·5	17·5	0·67
5.	86·9	96·4	6·2	0·85
6.	136·0	149·6	1·8	0·93
7.	50·8	80·6	14·5	0·76
8.	193·8	104·2	5·0	0·87
9.	133·0	148·0	—	—
	TUNGSTEN STEEL.			
1,	33·4	48·2	23·7	0·245
2,	36·7	53·5	19·5	0·277
3,	47·5	58·0	17·5	0·240
4.	35·4	50·0	23·5	0·4
5.	34·1	50·0	8·2	0·94
6	—	65·4	1·0	0·412
7.	29·3	54·8	23·5	0·549
8.	63·4	82·1	10·2	0·60
9.	95 0	126·1	2·5	0·975
10.	33·4	65·4	17·0	0·67
11,	73·5	94·5	8·5	0·76
12,	—	192 0	4·5	0·96
13.	44·0	74·8	9·0	—
14,	76·8	99·0	8·3	0·73
15,	—	150·0	2·8	0·99
16,	44·0	72·8	3·5	—
17,	76·1	96·4	2·0	—
	COPPER STEEL.			
1,	30·7	54·8	22·5	0·49
2,	70·1	77·5	17·5	0·41
3,	66·8	79·8	13·0	0·40
4,	46·0	59·0	18·6	0·50

COPPER STEEL.—*Continued.*

No. of Test.	*Elastic Limit per Sq. Mm.* — *kilogs.*	*Tensile Strength per Sq. Mm.* — *kilogs.*	*Elongation.* — *per cent.*	*Relations of Ruptured to Original Section.*
5,	100·0	122·3	6·2	0·76
6,	85·5	105·3	11·0	0·635
7,	30·7	54·8	22·5	0·49
8,	66·8	85·5	14·5	0·50
9,	—	110·0	2·0	0·97

MANGANESE AND SILICON STEEL.

1,	85·5	102·8	12·5	0·540
2,	46·9	70·7	22·5	0·454
3,	53·4	80·2	18·5	0·455
4,	118·8	126·1	10·7	0·53
5,	54·2	100·0	10·8	0·81
6,	103·4	112·3	7·8	0·69
7,	129·4	139·9	2·3	0·892
8,	46·1	63·7	22·2	0·41
9,	107·0	120·0	10·5	0·615
10,	92·2	112·2	14·2	0·50

MANGANESE STEEL.

1,	30·0	58·7	22·0	0·58
2,	76·8	102·8	12·5	0·55
3,	64·0	78·8	13·0	0·62
4,	34·6	61·6	14·0	—
5,	77·5	104·9	11·8	0·538
6,	69·4	92·2	10·0	0·54
7,	32·6	68·7	20·0	0·58
8,	84·2	108·4	8·5	0·635
9,	90·9	113·6	13·0	0·60
10,	40·1	75·5	16·0	0·645
11,	93·8	114·8	10·0	0·59
12,	86·2	99·3	11·8	0·565
13,	40·1	72·1	19·0	0·49
14,	102·8	123·5	7·5	0·69
15,	93·8	108·4	8·5	0·55
16,	109·6	124·0	8·0	0·69
17,	85·5	104·2	11·5	0·60
18,	41·4	81·3	29·0	0·74
19,	43·5	86·0	28·0	0·715
20,	37·2	96·4	41·5	0·635
21,	27·4	36·0	36·0	0·27
22,	36·7	48·2	24·5	0·275
23,	44·7	61·4	15·0	0·240
24,	33·2	67·9	14·0	0·79

MANGANESE STEEL.—*Continued.*

No. of Test.	*Elastic Limit per Sq. Mm.*	*Tensile Strength per Sq. Mm.*	*Elongation.*	*Relations of Ruptured to Original Section.*
	kilogs.	*kilogs.*	*per cent.*	
25,	13·0	97·8	10·5	0·578
26,	70·7	90·2	11·2	0·540
27,	31·3	64·0	21·5	0·578
28,	83·5	112·2	13·0	0·615
29,	73·5	93·8	10·5	0·54
30,	33·4	64·7	23·	0·495
31,	97·8	113·6	10·	0·615
	CARBON STEEL.			
1,	23·3	32·0	37·	0·267
2,	43·4	56·1	19·5	0·316
3,	33·4	52·8	26·5	0·465
4,	98·5	129·4	13·3	0·025
5,	67·4	92·2	12·8	0·52
6,	—	67·4	11·8	0·821
7,	65·4	99·7	5·0	0·93

[*To be continued.*]

ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

BY JOSEPH M. WILSON, A.M., C.E.
President of the FRANKLIN INSTITUTE.

[*Continued from vol. cxxx, p. 60.*]

Among other subjects that were still (1st November, 1888,) under consideration, the following may be of interest:

That teachers be informed that the Board do not pay so much attention to the percentage of passes obtained at the Government inspection, as to the general tone and character of the school-work.

That the number of mixed schools be increased in suitable districts, and that the staff of such mixed schools be arranged so that the number of women teachers shall not be less in proportion to the men teachers than the girls to the boys.

That in each mixed department under a master, an

appointment be made of a head assistant mistress, who shall be responsible for the teaching of needle-work to girls.

That advanced evening classes be established at the various pupil-teachers' schools, for instruction in science and drawing, commercial subjects and modern languages.

That the play-grounds attached to schools be used for the formation of clubs for hardy sports, gymnastic exercises and drill, and that the school organizations be used for the establishment of field clubs and swimming classes.

That the Chairman of the Board be asked to convene a meeting of local managers and others to consider the question of organized physical education out of school hours and to request personal help in the work.

Also, among the requests under consideration to be made for revision in the new code, may be noted; one for more freedom in choice in the selection of class subjects, so that the first class subjects need not necessarily be English; that short-hand be recognized as a specific subject; that provision be made for payment of a grant in the case of all girls of eleven years of age below Standard IV, who have received efficient instruction in cookery; that it shall be obligatory upon pupil-teachers to exhibit a knowledge of elementary science, in some form, at their annual examinations; and that application be made to the science and art department, that their syllabus be remodelled, so as to supply a greater stimulus to drawing being taken in combination with geometry and measurements, in preparation for manual work.

These recommendations, etc., are given in detail, as it is possible they may offer valuable suggestions to those interested in such matters. The whole tendency appears to be towards the encouragement of manual training, and the teaching of science, drawing and practical subjects generally.

The teachers are paid fixed salaries irrespective of the government grant earned, and the pupil-teachers are not only teachers in the schools, but are also indentured to the Board as apprentices.

There are twelve central schools for the instruction of

pupil-teachers, the seniors, or those in the third and fourth years of apprenticeship, attending these schools on two half-days and on Saturdays, and the juniors, or the first and second-year probationers and the second-year pupil-teachers and candidates, attend on part of each day and on Saturday mornings. The head teachers of their own schools are also required to exercise a strict moral supervision over their pupil-teachers; to see that, they attend regularly and punctually the pupil-teachers' schools, and that they give proper attention to the preparation of their lessons, and to their private studies; to correct their notes of lessons; to direct and supervise their methods of teaching; and to examine, sign and date, each week, the pupil-teachers' report book, and to see that it is properly kept.

The Board considers that it would be useless to teach children the mechanical art of reading unless they were inspired with a love for reading, and in order to encourage this it has provided lending libraries of carefully selected books for the children. To encourage thrift among the scholars, the question of penny banks in the board-schools has been taken into consideration, and arrangements have been made for establishing such banks, wherever practicable, in both boys' and girls' departments. Some are already in working condition.

Certificates are given in the senior departments to all Standard children who have passed the Government examination in all the elementary subjects, and reward cards, prizes and medals are given for regular and punctual attendance. The National Health Society has also provided funds for a certain number of prizes to girls, after examination in the laws of health and domestic economy, and private benefactors have provided sums of money for the purpose of founding scholarships and exhibitions, intended to connect public elementary schools of the metropolis with schools of a higher grade.

There are also a number of other scholarships of various kinds, and all of these act as an incentive to study, and afford those who gain them great advantages in obtaining a higher education.

EVENING CLASSES.

Previously to the year 1882, there were no evening classes, excepting some which were opened as an experiment and afterwards closed, and some which were not under the control of the Board, but in the autumn of that year, the Board, feeling that there was a growing necessity for elementary instruction in the evening, opened elementary evening classes in eighty-three schools, conducting them in accordance with the elementary education acts and government code and giving the same instruction as in the day-schools. To show the progress of these classes it may be stated that in 1882–83 the number of pupils admitted was 9,064, giving an average attendance of 1,707, and 1887–88 the number admitted was 16,320, with an average attendance of 5,805. These classes are in session only during the winter months, the first term being from the end of September to the end of the week preceding Christmas week, and the second from the second week in January to the end of the week preceding that in which Good Friday falls. The classes are generally held on three evenings in the week between the hours of 7.30 and 9.30, and the two sexes are not taught in the same building at the same time. The fee (except in a few cases) is three pence per week or two shillings a term.

Young persons over fourteen years of age, and children who are not under legal obligations to attend day-schools, may attend the evening classes, and with a view of inducing them to commence doing so as soon as possible after they discontinue day-school attendance, there is kept in every day-school a book, entitled *Old Scholars' Book*, in which each scholar who becomes exempt from legal attendance at day-schools is, when leaving such school, requested to enter his or her name, address, Standard last passed, date of leaving school, and desire as to attending evening classes. It is the duty of the head teacher to see that these entries are properly made and to urge attendance on the scholar. Immediately after, and frequently during the session, invitations are sent out to those on these lists, asking them to join the classes.

In order to also encourage the pupils to attend regularly

and to sit at the government examinations, prizes of books are given to pupils who make attendances at the rate of eighty-five per cent. or more, of the times that the classes are open during the session, who sit at the government examination, and who conduct themselves satisfactorily. Certificates are awarded to those who pass in two or more subjects at the examination.

Special classes for instruction in French are opened in connection with the elementary classes where twelve or more pupils present themselves, and special fees are charged. Special classes in practical cookery were also opened as an experiment in 1888 at four centres in different parts of the metropolis, giving two hours' instruction on one evening per week, at a fee of one penny per lesson, but the experiment was not a success, owing, it is believed, to the unfavorable conditions of the code of the Educational Department, that only pupils belonging to the elementary classes could attend these special classes; that the pupils to earn a grant must make a certain number of attendances at both kinds of classes, and that the special classes should be held on an evening when the elementary classes did not meet; conditions that necessitated absence of the pupils from their homes on four evenings in the week.

Recreative evening classes for instruction in recreative and practical subjects have been introduced in answer to a memorial request from the London Trades Council, with excellent results. Such matters are taken up as music, drill, gymnastics, singing, drawing, modelling, wood-carving, needle-work, chemistry, physiology, electricity, geography, history, etc., oral teaching and object lessons, illustrated with the magic lantern. This work is carried on under the auspices of the "Recreative Evening-Schools Association," of which H. R. H. the Princess Louise is President. Only pupils in the elementary classes are allowed to attend the recreative classes. The effect has been to largely increase the attendance at the elementary classes and to bring about a close connection between the two.

In addition to the establishment of elementary classes, considerable work has been done with advanced classes for

instruction in the subjects recognized by the science and art department and the city and guilds of London Technical Institute, also in book-keeping, short-hand, singing and the preparation of candidates for civil service. Only responsible teachers of elementary classes are allowed to conduct the advanced classes.

The following table may be of interest, as showing the attendance at the classes for the session commencing at the end of September, 1887, and ending at Easter, 1888, in the cases of short-hand, singing and civil-service classes, and at the May examinations in the cases of the science and art classes. All the subjects were taught in connection with the science and art department, except carpentry and plumbing, which were taught in connection with the city and guilds of London Technical Institute, the subject taught in classes for the preparation of candidates for the civil-service and book-keeping, German and short-hand.

Subject.	Number on the Roll.			Average Attendance.		
	Male Pupils.	Female Pupils.	Total.	Male Pupils.	Female Pupils.	Total.
Agriculture,	13	36	49	10	28	38
Animal physiology,	15	19	34	13	16	29
Art,	33	51	84	23	34	57
Book-keeping,	1	11	12	1	10	11
Botany,	10	—	10	7	—	7
Building construction,	108	—	108	58	—	58
Carpentry,	10	—	10	6	—	6
Chemistry, inorganic,	90	—	90	66	—	66
" organic,	40	—	40	22	—	22
" theoretical and practical,	15	1	16	9	1	10
Civil service,	16	2	18	14	1	15
Geometry, P., P. and S.,	159	—	159	107	—	107
German,	12	8	20	8	5	13
Hygiene,	9	3	12	7	2	9
Machine construction,	130	—	130	106	—	106
Magnetism and electricity,	225	6	231	170	3	173
Mathematics,	108	2	110	77	2	79
Mechanics,	81	1	82	58	1	59
Physiography,	87	32	119	68	25	93
Plumbing,	16	—	16	9	—	9
Short-hand,	850	39	889	690	37	727
Sound, light and heat,	79	—	79	55	—	55
Steam,	20	—	20	16	—	16
Total,	2,121	911	2,332	1,600	165	1,765

At the examinations held by the Science and Art Department and by the city and guilds of London Technical Institute, 967 pupils were presented, of which 163 passed in the first class, 464 passed in the second and 340 failed.

Special committees of local managers, composed of ladies and gentlemen residing in the locality of the classes, assist the committee in their work, and one of the managers acts as honorary correspondent.

The recreative and advanced classes involve no extra expenditure on the part of the Board, a Provisional Committee, of which the Archbishop of Canterbury is President, providing the necessary funds, apparatus, etc. The cost of conducting the elementary classes was not quite eleven shillings per pupil.

Matters in connection with the Industrial School Committee (ragged schools, etc.), and the other committees are not pertinent to the present inquiry.

SLÖJD.

Mention has been made of the "Slöjd" system of handicraft in connection with the London board-school.

Slöjd instruction in its great development is due to Sweden, but the original realization of the idea belongs to Finland, through Uno Cygnaeus, the founder of its public-school system, and "the statute of 1866, respecting the organization of this school system in the Grand Duchy of Finland, drawn up chiefly according to his recommendations, is certainly the first common-school ordinance which adopts *technical handwork* as an obligatory exercise in seminaries, and Slöjd for boys in the country schools."

I am indebted for considerable information on the Slöjd schools of Sweden and Norway to a report on "Handwork Instruction in Sweden," by Prof. John M. Ordway, of the Massachusetts Institute of Technology, published in the *Forty-sixth Annual Report of the Board of Education*, Boston, Mass., and republished in the *Parliamentary Report of the Royal Commissioners on Technical Instruction*, London, 1884. In this report are valuable extracts from a publication, entitled *Work Schools*, by a Norwegian school inspector, H. K. Kjennerud (Kristiania, 1882). I have abstracted freely from this paper, only regretting that it is not of a later date.

Slöjd is a word derived from the old Norse language,

and is peculiarly Swedish in its present signification, with a meaning very comprehensive, but very difficult to define. It implies "work with the hands and with simple tools." The Swedish Slöjd schools have been in existence only about nineteen or twenty years, omitting consideration of the Willinsk school in Göteborg and the Prince Carl's Institute at Gâlö, which are not schools in the ordinary sense, but institutions established as homes for children. These schools have increased very rapidly in Sweden until it is becoming very general in that country to combine the Slöjd instruction with that in the common schools, and to employ the school-teachers themselves to teach it.

This teaching, however, is not limited to schools for children, and one will find in Sweden, here and there, schools and courses of Slöjd instruction for grown persons. There is a Slöjd seminary at Nääs, two Swedish miles from Göteborg, founded and endowed by Herr Abrahamson, as a private institution to supply the demand for teachers. The superintendent of this seminary is Herr Salomon, and it was under him that the teachers forming the Slöjd Union in England, of which he is President, were trained, the certificate of efficiency from Nääs being a requirement for membership in that Union. The Union of Slöjd Teachers in England has for its objects the mutual help of the members in all matters relating to Slöjd and the promulgation from time to time of the principles of that system, by means of pamphlets and in other ways, the members pledging themselves to adhere to the educational principles of Nääs, in order to maintain a high standard of efficiency.

The work in the Nääs Slöjd Seminary is carried on according to a series of models arranged in systematic order, the catalogue containing 216 numbers and divided into the following sections: Models, full size; polished work, wood-carvings, models on a smaller scale. Seminary students are capable of working all the numbers. Objects coming under the denomination of toys are particularly excluded.

The fundamental principles of the instruction given in this school are well explained by a circular distributed by the Slöjd Union, of which the following is a copy:

A.—AIM OF THE INSTRUCTION.

Whilst the elementary schools prepare the children *indirectly* for life, the chief aim of the teaching of Slöjd is to give the pupils formal instruction; that is, to develop their mental and physical powers. It has also for its material and practical aim the acquisition of general dexterity of hand.

This formal education which Slöjd has in view aims principally at:

Instilling a taste for and love of work in general.

Inspiring respect for rough, honest bodily labor.

Training in habits of order, exactness, cleanliness and neatness.

Accustoming to attention, industry and perseverance.

Promoting the development of the physical powers.

Training the eye and sense of form.

B.—THE METHOD AND MEANS OF INSTRUCTION.

I.—General Principles.

Attendance at Slöjd instruction should be voluntarily on the part of the pupils. In order to ensure this the work must fulfil the following conditions:

(1) It must be useful.

(2) It must not require fatiguing preparatory exercises in the use of the various tools.

(3) It must afford variety.

(4) It must be capable of being carried out by the pupils themselves.

(5) It must be *real* work, not play.

(6) It must not be so-called knick-knacks; that is, articles of luxury.

(7) It must become the property of the pupil.

(8) It must correspond with the capabilities of the pupils.

(9) It must be of such a nature that it can be completed with exactness.

(10) It must admit of neatness and cleanliness.

(11) It must exercise the thinking powers and not be purely mechanical.

(12) It must strengthen and develop the bodily powers.

(13) It must assist in developing the sense of form.

(14) It must allow of the use of numerous manipulations and various tools.

II.—The Teacher.

(1) The instruction must be given by a trained teacher, if possible by the same teacher who instructs in intellectual subjects.

(2) The teacher should conduct, superintend and control the work; but guard against directly putting his hand to it.

III.—The Age of the Pupil.

In order to follow with advantage the course of instruction, the pupil ought to have reached that stage of development usually attained at the age of eleven.

IV.—Branches of Instruction.

The simultaneous employment of several different kinds of Slöjd acts detrimentally for the following reasons:

Already a sufficient number of subjects are taught in the school and every different branch of Slöjd is a subject in itself.

The time to be devoted to this work is short and limited.

By different kinds of work the interest of the pupils would be easily diverted, therefore the instruction in Slöjd should be confined to one branch.

For the above-mentioned standard of age *wood-slöjd* is the most suitable. It includes carpentry, turnery and wood-carving.

Slöjd-carpentry differs from trade-carpentry, in the following respects:

(1) As to the character of the objects made: in general the objects are smaller than those made in the trade.

(2) The tools which are used: for instance, the knife is the most important tool in wood-slöjd—in carpentry, it is rarely used.

(3) The method of working: in trade-carpentry, there is division of labor—in Slöjd, none whatever.

Turnery may be taken as a different branch of instruction, and as such be quite well separated from wood-slöjd.

V.—The Number of Pupils.

Individual instruction is generally advisable--this is especially the case with Slöjd, which, on fundamental and practical grounds, cannot be taught as a class subject; therefore the number of pupils taught by one teacher must be limited.

VI.—The Models.

In order to make the instruction as intuitive as possible, models ought to be used in preference to drawings. The form should be sketched either directly, by placing the model on the piece of wood, or by means of a diagram drawn with ruler and compass on the wood.

In arranging a series of models, the following points must be observed:

A.—*As to the Choice of the Models.*

(1) All articles of luxury are to be excluded.

(2) The objects made are to be capable of being used at home.

(3) They are to be such objects that the pupils can finish them without any help.

(4) They are to be such objects as can be made entirely of wood.

(5) The work is not to be polished.

(6) As little material as possible is to be used.

(7) The pupils are to learn to work both in hard and soft woods.

(8) Turnery and carving are to be used as little as possible.

(9) The models are to develop the pupil's sense of form and beauty.

In order to attain this, the series must include a number of examples of form, such as spoons, ladles and other curved objects which are suitable for execution by the hand *alone*, guided by the eye.

(10) The whole series must be so arranged as to teach the pupils the use of the necessary tools, and to know and carry out all the most important manipulations connected with wood.

B.—*As to the Arrangement of the Models.*

(1) The series must progress without break from the easy to the difficult, from the simple to the complex.

(2) There must be a refreshing variety.

(3) The models must follow in such progressive order that by means of the preceding ones, the pupils may obtain the necessary aptitude to make the following ones without direct help.

(4) The models must be so graduated that at every stage the pupil is able to make an exact copy, not merely an approximate one.

(5) In making the first models only a small number of tools must be used; as the work progresses the number of tools and manipulations should gradually increase.

(6) At first the knife, as the fundamental tool, should be mostly used.

(7) Rather hard woods should generally be used for the first models.

(8) At the beginning of the series the models should be capable of being quickly executed, and gradually models which require a longer time should be given.

Mr. J. S. Thornton, of Victoria Park School, Manchester, Chairman of the first general meeting of the Union of Slöjd Teachers, in his opening address said (I quote only extracts from this address) that education in England is too one-sided and literary; that it is more fitted to make clerks than to form capable craftsmen; that what was needed was something that would combine the exact training of the eye and hand, which drawing affords, with the activity, the freedom and exhilaration of movement which are characteristic of the national games. And that this something was found in the use of elementary tools, the absence of which from the school curriculum has been regretted by men as wide

apart as Luther, Locke and Rousseau. Many teachers are more than half convinced—those who have been to Nääs are entirely convinced—that a cunningly devised instrument, ready to the schoolmaster's hand, has there been forged, which will make good the defects that have so long been calling for a remedy. It is believed that it is Slöjd, rather than what is usually known by the term manual training, that will enable the required result to be brought about in the ordinary schools. In this connection, it is of the very essence of Nääs Slöjd that it be taught by the form master, *properly trained*, and not by the village carpenter or other artisan, however intelligent.

The group of exercises, of which the Slöjd models are the embodiment, are a noteworthy example of very fine graduation. The various processes which are necessary to produce all the models of a series, have been subjected to careful analysis; and then the elementary manipulations, so obtained, are by a corresponding synthesis grouped together, in a varying order, to form model after model, but in such a way that the ratio of the new elements to the old, always a small one, shall actually diminish as the work proceeds. Nowhere out of Euclid does any subject proceed with such an ordered march. The ideal is that no single model, however complex, shall give more trouble to the advanced student than the simplest one does to the beginner.

Slöjd is educational rather than technical. Sir John Lubbock tells us there are two theories with regard to manual training: "The one treats the school as subordinate to the workshop; the other takes the workshop and makes it a part of the school. The one seeks to make a workman, the other to train up a man." Schoolmasters are often urged, and never more so than now, to let their pupils begin to specialize at too early an age. And it might be thought that in advancing the use of tools as part of the ordinary school curriculum, we were yielding to this pressure. It is not so. The Nääs wood-slöjd, in its principles and details, has for its direct aim the development of all a child's power, physical, mental, moral. It paves the way for technical instruction in after years, but is no part of technical instruc-

tion proper. It is intended to give general manual dexterity, and prepares for no special trade or profession.

In the Slöjd-room, complete articles are made from the very commencement; whereas, in most other kinds of manual training, the young pupil is for long periods kept at mere exercises which seem to him to lead to nothing. There can hardly be a question which of the two methods is the more likely to call forth the pupil's interest.

These extracts from Mr. Thornton's address are sufficient to show what Slöjd is expected to accomplish. An address made at the same meeting by Miss Teskey, of Sydenham College for Ladies, gives good evidence that this method of teaching is applicable to girls as well as boys. Miss Teskey stated that her attention had been first drawn to the subject of Slöjd in 1887, and that she took up the study of it principally with the view of introducing it for the pupils in the school with which she was associated, as a means of active bodily recreation. She had long noticed with concern how girls spent their spare time and holidays in reading, writing, drawing, painting and needle-work, the only active exercise they took by way of recreation being dancing. In summer, of course, they had plenty of out-door exercise, but in winter they were greatly in need of some *interesting active occupation* to counteract this continual sitting and stooping over books, drawing, etc. She soon became convinced that Slöjd afforded interesting and certainly active bodily work, and that it might be made a most important factor in the development of the physical powers; therefore, on this account alone, would be invaluable to girls of the upper classes. But most of all she was impressed with the educational value of Slöjd in the moral training of the girls. Unconsciously they learn self-reliance, accuracy, perseverance—all qualities which need very especial cultivation in their case.

Miss Teskey began in October, 1887, with a class of nineteen or twenty girls, varying in age from eleven to eighteen. The attendance was voluntary and came out of the recreation time. The work was a gratifying success; the interest, which was very great at the beginning, was maintained

throughout the course, and the advent of each fresh model was hailed with delight, while the greatest anxiety was evinced for the passing of a model. The models were carefully examined when finished and if not up to the Nääs standard, were rejected. The work was remarkably good, not more than five or six models failing to pass, and there were no accidents from the use of the tools.

Miss Teskey stated that Slöjd fulfilled all that it proposed. It developed the pupils physically and mentally, the physical advantage being soon apparent in individual cases as well as in the whole class, and as to mental training, it roused the indolent mind by giving it something definite, tangible to think about and do, and excited a taste for the love of work. This was shown in a very marked manner in several cases, and some who before would sit idly over their lessons for an hour or two, quite unable to think or to concentrate their attention, got through their lessons briskly and cheerfully in order to have time to spare for Slöjd. Any teacher of Slöjd, says Miss Teskey, would be soon convinced of its great power as a means of training the observation and cultivating the eye and sense of form.

The Slöjd Association of Great Britain and Ireland is another organization of the same type, having for its object to make Slöjd known to educators and the public generally, and to unite all those who are interested in its promotion; to found a Slöjd training institute for teachers, which shall also serve as a centre where information on Slöjd work and principles can be obtained and become the headquarters for branches throughout the country; to endeavor to make Slöjd *national* in character by adapting the practical work to English habits and requirements, while adhering to its principles, which are equally true for all countries; and to establish a Slöjd register in which shall be entered the names of the teachers and schools where Slöjd work has been inspected and approved by the Association.

The President of this Association states that "there is a growing feeling of discontent with the present system of national education, and all who have studied the subject are agreed that it is one-sided, mechanical and too exclusively

literary." "Most thinkers are likewise agreed (though they differ as to the means) that the defect lies in the neglect of physical and manual training." "For young children this is already provided by the kindergarten." "To draw out all the faculties, to satisfy the active and constructive instincts of children, to arouse their interest and stimulate their curiosity—such is the method of Froebel." "The Slöjd system is based on the same principles, and it carries on the work of the kindergarten in a form suited to the growing physique and maturer powers of older children."

In the Swedish schools the time devoted to Slöjd appears to be six to eight hours per week, and the number of hours instruction which each boy receives depends upon the number of boys in the school from eleven to fourteen years of age, the classes being limited to about sixteen at a time. The subjects taught are joinery, turning, simple carving, basket-work, and in some cases, blacksmithing, wire-working, shoemaking, tin-plate working, painting and bookbinding. Courses for the improvement of Slöjd teachers are generally held in the summer vacation.

The children do not appear to be by any means confined to working according to a system of models, and there are instances where they are kept at the same kind of work for a long time, really doing a manufacturing business in such things as apparatus for use in the common schools, etc. Schools have the privilege of purchasing models from the Nääs Slöjd Seminary at a low price.

In one of the schools it is specified that the instruction shall be such that the pupils will acquire dexterity in making articles needed and used by working people, rakes, spades, axe-handles, etc. The boys are sometimes given what they make, and at other times have half the value of their work, or may buy it at half price, while there are cases where the productions are kept by schools. Poor children are allowed their shoemaking free, while those who have the means, pay for the materials, etc. The practice differs in different localities.

In the Upsala län, a Slöjd Committee makes arrangements for inspecting the work-schools of the län. It assists

the schools by contributions of money, certain conditions being fulfilled, arranges to lend models and sometimes tools. There is a store in Upsala for the sale of domestic industrial products, and the products exhibited there, comprising men's and women's work, useful objects and articles of luxury in infinite variety, show that this industry is in an advanced state. Such agencies also exist in other parts of Sweden, and are really a necessity to make domestic industry a success. That kind of aid is now extended to women in our own city by means of the Philadelphia Exchange for Women's Work.

At Göteborg, Slöjd is obligatory for the older classes in all the common schools, where, in 1880, about 1,400 children were taught. Here the working time of the pupils is ten hours per week. The school is considered as preparatory for hand-work, and the teachers are without exception hand-workers. From one to three months are spent in each department, and the remaining time, when possible, is devoted to that work for which the pupil shows the greatest interest and aptitude, the aim being not to acquire general dexterity as much as expertness in some special direction.

Pupils receive a profit from their work, and at examinations, premiums are given to the most skilful, if also satisfactory in their school studies.

The Slöjd schools of Göteborg have attracted much attention on account of the remarkable skill with which they are managed, but there appears to be a question "whether in this management, there is not a want of a right pedagogic view, and whether the work-schools have not come to run in the service of the trades and in a track which they should not go."

In Wernersborg, Slöjd has been made compulsory in the common schools since 1872. Tailoring is one of the branches of instruction, but boys do not as a rule take an inclination to this. The workshops are small and the pupils are so divided up that there will not be more than eight or ten in a class. Orders are taken by the school, and auction sales are made of things worked up.

In Norway, the principal schools are at Kristiania and

Fredriksstad. The latter is exceptional in that it is maintained by the common-school funds. Hardly anywhere in Norway have greater sacrifices been made for hand-work construction than in Fredrikshald. The Fredrikshald Slöjd Union was formed in 1874, with the object of laboring for the advancement of domestic work and habits of industry. A work-school was opened immediately after New Year, 1876, for forty-eight pupils, soon increasing to 130. Gifts of subscribers and others, also contributions from the city, all aided in helping the work, and, in 1882, the school moved into a new building, with largely increased classes, and in addition, a work-school for boys was established in one of the suburbs of the city. Some of the pupils are common-school boys and some are from the Latin school. The regular term is from the first of September to the end of April, but Latin school pupils can begin on the first of October. It is the duty of the teacher to instruct seven hours in the day and in addition, to spend six hours a week in keeping the tools in repair, etc. At the date of the information at my disposal, concerning this school (1882), there were, besides the regular teacher, who was very skilful as a carver and could in addition give instruction in basket-work, brush-making, painting and bookbinding, also five teachers by the hour: one shoemaker for eighteen hours, one tailor for six hours, one bookbinder for eight hours, and one journeyman joiner for six hours a week.

Besides the regular work of the school there are, every year, extra courses. Women and girls are instructed in wood-carving and bookbinding; the manufacture of wooden shoes is taught and also the making of various simple articles of furniture.

In the department for joinery, each work-bench is provided with a drawer containing three chisels, one rasp, one file, one rule, two squares, one brad-awl and one draw-knife. In addition, every bench has a small jointer plane, a jack plane, a smoothing plane, a saw, a mallet and a hammer. There are other tools which are used by the pupils in common.

From New Year, 1881, work has been carried on according

to a systematic collection of models, the idea being derived from the Nääs Slöjd Seminary, but the order of work differs in many important points from that of Nääs. The list of models is not nearly as large, but there are generally included from two to six different articles under one number of which the pupil, according to circumstances, has to make one or all. The reason for this arrangement is partly that if each number had only one article placed to its credit, so many of a kind would be made as to render them unsalable, and partly to give the pupil a chance of making a choice.

The Nääs system begins with the use of a knife, while at Fredrikshald the pupils commence with the use of the saw, the plane and the file. Whittling exercises are taken at a certain time in the year, several weeks in succession, by all classes in joinery at the same time.

At Nääs, pieces of turning and simple carving are placed in the list, while here the turning work is kept separate, and it is made voluntary on the part of the pupils. A very few pieces of carving are made by requirement, but the student can devote himself more exclusively to wood-carving, if he wishes, after having reached a certain stage in the course.

After trying tailor work for two years it was decided to give it up, as it was not a success. Painting (house and cabinet painting) is being taught successfully and also bookbinding. Instruction in drawing was commenced in the autumn of 1881, with three hours' instruction weekly, after the Stuhlmann method, which is in general use in Sweden in all technical and other public schools, where such instruction is given. This method has the advantage of "making the first trivial exercises interesting to the pupils, who have immediate satisfaction of forming very pretty figures and patterns, without its being difficult, or departing from the common pedagogic principle of going from the easier to the more difficult." "The drawing is done first in a book ruled in squares, and next in a dotted one according to the teacher's sketch on a dotted blackboard, painted for this method." "Further on, after figures in straight and curved lines have been drawn, with the help

of lines and points in the two books, there are commonly used drawing books for geometrical figures according to the teacher's sketch on the black-board, with the use of the Stuhlmann plates." "Then follow other figures, and finally, drawing from plaster, objects in *bas-relief*, blocks without shading, plaster figures in *alto-relievo*, and blocks with shading."

In reference to the children, the methods of ordinary schools are carried out as far as possible; regard is had to good behavior and every endeavor is made to inculcate habits of courtesy, neatness and order.

It was found, as a rule, that only the younger boys came to school and that they left it when reaching an age at which they would derive the most profit from their instruc tion. The principal reason seemed to be that older boys were more useful at home and could often earn wages for work, also that they disliked the restraint of the school. To encourage a longer attendance of the pupils, it was decided, instead of giving them premiums as rewards for diligence, constant attendance and good conduct, to credit them (in those branches of work, in which the school furnishes materials and keeps the products) with wages, which are regularly entered in a work-book and are not paid out until they leave the school, after having been for a certain time constant pupils. These wages do not, as a rule, exceed half the value of the work, and they depend on its salability, but that work which is done without the teacher's aid receives the highest pay. The work is judged in the pupil's presence by inspectors and teachers jointly, and any observed inaccuracy is pointed out on this occasion. When the pupil leaves school, instead of money, a savings-bank pass-book is given him, with encouragement to use it for future savings. It seems to be the opinion that the school will be more highly esteemed and more constantly attended if there is fixed a fee, ever so small, for instruction, and very small charges are therefore made. This enrolment fee has served to do away with the inconvenience of having a great many report themselves, attend a few time, and finally disappear.

[*To be continued.*]

THE OXIDATION OF SULPHIDES BY MEANS OF THE ELECTRIC CURRENT.

BY EDGAR F. SMITH.

[*Read at the Stated Meeting of the Chemical Section, June 17, 1890.*]

In the Proceedings of the Chemical Section of the FRANKLIN INSTITUTE, **1**, 52, and the *Berichte* **22**, 1019, a preliminary report was published, describing a rapid method for the conversion of sulphur into sulphuric acid through the agency of the electric current. It was there demonstrated that the sulphur in the mineral chalcopyrite, for example, was completely oxidized to sulphuric acid in ten minutes, and that the oxides Fe_2O_3, CuO, etc., were eliminated from the analysis, so that the barium sulphate finally weighed was perfectly white in appearance, and not contaminated with the impurities usually accompanying it when precipitated from solutions containing much iron, etc.

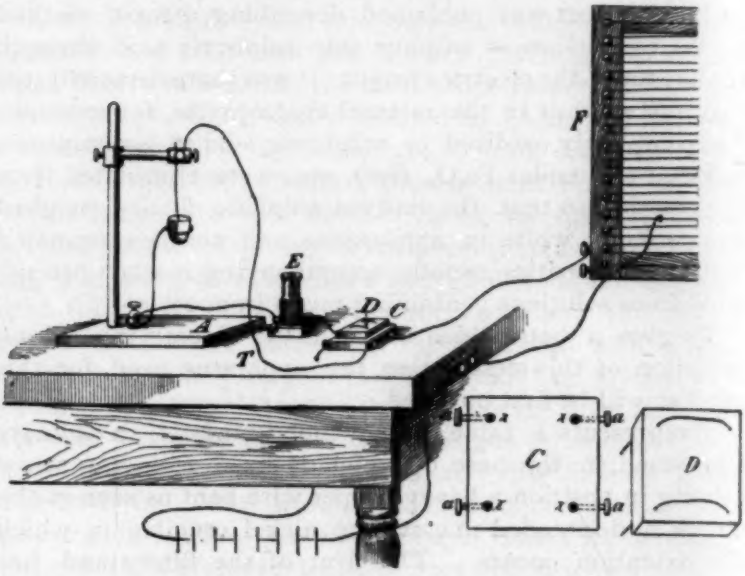
To give a better idea of the mode of carrying out an oxidation of this description, the apparatus used for this purpose will be first outlined.

T represents a table upon which stands *A*, an ordinary filter-stand, in the base of which is fixed a binding screw holding in position a heavy copper wire bent as seen in the sketch, and intended to carry the nickel crucible in which the oxidation occurs. The arm of the filter-stand has attached to it a binding screw holding a heavy platinum wire, as well as the copper wire generally in connection with the anode of the battery. *E* is a Kohlrausch ampèremeter, registering ampères and half ampères; this is in connection with *C*, a block of wood screwed or nailed to the table. There are four depressions (*x*) in *C* containing a few drops of mercury, in contact with the binding screws (*a*). *D* is the movable top of *C*; the wires crossing it project on the under side and rest in the mercury cups (*x*). When *D* is so arranged that the wires on its upper face run in the direction of the

dart, the ↑ crucible becomes the anode of the battery, whereas if ↓ they have a horizontal position, ⟶ the crucible is the cathode.

F is a resistance frame, consisting of about 500 feet of common iron wire arranged upon a light wooden parallelogram. It should always be in the circuit.

The movable cap *D* is necessary and important. It enables the operator to change the poles quickly—to reverse the current at a moment's notice. In the oxidations to be described later on, this was frequently necessary, chiefly



because when the crucible served as cathode in many of the decompositions there often occurred a considerable deposition of metal upon its sides, and in the act of separating this metal enclosed undecomposed material and withdrew it from the field of oxidation. In such cases, by making the crucible the anode, as above indicated, the mineral matter will be liberated, and upon coming in contact with a large oxidizing surface, all the sulphur contained in it will be converted into sulphuric acid. The crucible should always be covered during the oxidation.

OXIDATION OF THE SULPHUR IN SULPHIDES.

In the oxidations given later, nickel crucibles 1¼ inches high and 1⅜ inches wide were used; but a more advantageous form, one which should always be employed when more than 0·15 gram of material is used, would measure 2 inches in length and 1½ inches in width. In such a vessel, place 25–30 grams of pure potassium hydroxide (not sodium hydroxide), and warm the same until the excess of moisture is expelled. Bring the weighed sulphide into the crucible, connect the latter with the copper wire shown in the sketch, and lower the platinum wire so that it extends a short distance below the surface of the molten mass. The current is then made to pass by bringing a metallic cup, connected with one pole of the battery, in contact with one of the wires of the resistance frame *F*. The sulphur will be completely oxidized in from ten to twenty minutes. Interrupt the current, allow the crucible and contents to cool, then place the same in water. In a few minutes, all but the insoluble oxides will have dissolved. Filter, acidulate the warm filtrate with hydrochloric acid, and precipitate the sulphuric acid in the usual manner. If, upon adding acid to the alkaline solution the latter becomes turbid, from separated sulphur, it is an indication that the oxidation was incomplete. Observe closely whether sulphur dioxide is liberated even when the liquid remains clear. Never omit the examination of the residue remaining on the filter, after the alkaline solution has been filtered. The caustic alkali must always be tested for sulphur before using it in this work. It is well to estimate the impurities in the alkali and deduct them, in each determination, from the barium sulphate found.

To ascertain to what extent this method could be applied in oxidizing sulphur, the following minerals, representing all the various classes of natural sulphides, were subjected to experiment:

SPHALERITE (ZnS).

No difficulty was experienced in oxidizing the sulphur of this mineral. A current of one ampère (= 10·45 cc. electro-

lytic gas per minute) was amply sufficient for the purpose. When the mineral was added to the melted caustic potash and the current applied, the mass assumed a muddy appearance, which it retained for ten minutes when it became white and froth-like. It was discovered, by experiment, that this appearance indicated the complete oxidation of the sulphur.

(I)	0·1195	gram	mineral,	20	grams	alkali,	1 ampère (time, 20 minutes), gave	32·97 per cent. S.
(II)	0·1025	"	"	"	"	"	"	32·96 "
(III)	0·1180	"	"	"	"	10	"	32·80 "

By oxidizing the sulphur in a fourth portion with nitric acid and potassium chlorate, 32·90 per cent. sulphur was obtained.

A specimen of Joplin (Mo.) blende gave 32·60 per cent. and 32·80 per cent. S. by the nitric acid method, while by the electrolytic method 32·90 per cent. S. was found.

An impure sphalerite, locality unknown, in which there was considerable gangue and other admixtures, gave 29·8 per cent. S. when oxidized with nitric acid, and when acted upon in alkaline solution by a current giving one ampère of electrolytic gas per minute, the sulphur found was:

(I)	29·23	per cent.	S.
(II)	29·45	"	"
(III)	29·68	"	"
(IV)	29·67	"	"
(V)	29·90	"	"
(VI)	29·58	"	"

CINNABAR (HgS).

Very pure material was employed in this oxidation. Several trials were required, in order to learn the proper conditions for successful working. The tendency of this mineral, when finely divided, was to collect in lumps, which appeared to rise and fall in the alkaline solution; in order to bring every particle of material within the field of oxidation the current was reversed every few minutes. By doing this the sulphur was completely oxidized in twenty minutes or even in less time. If the precaution just mentioned with reference to the reversal of the current be not heeded more time will be required for complete oxidation and even

then it will be doubtful whether the sulphur is fully converted into sulphuric acid. Twenty-five grams of caustic alkali were used in each experiment with this mineral.

0·1089 gram cinnabar gave 13·82 per cent. S., while the required percentage is 13·79.

A current of two ampères per minute was used.

GALENITE (PbS).

There is no difficulty in oxidizing this mineral. The same quantity of alkali and the same current strength were employed here as in the mineral immediately preceding:

(I) 0·1093 gram galenite gave 14·30 per cent. S.
(II) 0·1092 " " 14·60 " "

Another portion in which the sulphur was oxidized by heating the mineral in a current of chlorine gave 14·30 per cent. S.

ARGENTITE (Ag_2S).

No difficulty was encountered in oxidizing this mineral. The decomposition was made with conditions analogous to those already described. Silver did not pass into the alkaline solution, so that when the sulphuric acid was precipitated, barium chloride was employed as usual. The specimen analyzed being exceedingly pure, it was not thought necessary to determine the sulphur by any other method. None of it remained unoxidized:

0·1032 gram argentite gave 13·04 per cent. S; required 12·90 per cent. S.

CHALCOCITE (Cu_2S).

Thus far this mineral has resisted all efforts to convert its sulphur into sulphuric acid. Repeated attempts have been made, but not more than half of the sulphur contained in the mineral was oxidized, notwithstanding the current was very much increased in each trial. Since some time may elapse before another opportunity offers itself to continue experimentation with this mineral, it need only be stated that a modification of the usual method will be tried upon it. The copper and sulphur are evidently in very intimate union.

MOLYBDENITE (MoS_2).

The sulphur in this mineral is given up readily to the oxidizing influence of the current. One annoying feature is that the fine mineral particles are so very light that they are apt to be carried up and adhere to the cover crystal. In this oxidation the poles should be repeatedly reversed. The result given below is from a sample that contained much quartz, etc. The residue, however, gave not a trace of sulphur when tested for it.

0·1045 gram mineral gave 0·2785 $BaSO_4$ = 36·60 per cent. S.

STIBNITE (Sb_2S_3).

While a current of two ampères was employed in this oxidation, the sulphur can be completely changed to sulphuric acid with one ampère. Three trials proved this conclusively.

0·1095 gram mineral gave 0·2230 $BaSO_4$ = 27·91 per cent. S.; required sulphur, 28·5 per cent.

ORPIMENT (As_2S_3).

Pure material could not be obtained, so that the experiments were made with inferior mineral, and the greatest care was given the oxidation, so that sulphur was not afterwards discovered in the insoluble residue.

0·1150 gram sub. gave 0·2922 gr. $BaSO_4$ = 34·90 per cent. S.
0·1044 " " 0·2721 " = 35·79 " "

The arsenic was also oxidized to arsenic acid. Several tests proved the conversion to be quantitative. Results obtained in this direction will be published later.

JAMESONITE ($Sb_2S_3Pb_2$).

The sulphides of lead and antimony offer no difficulty in the oxidation of their sulphur. This sulpho-salt is decomposed with equal facility. A current of two ampères per minute was employed. The crucible was the anode for ten minutes, and the cathode for an equal period.

(I) 0·1078 gram mineral gave 0·1426 gr. $BaSO_4$ = 18·16 per cent. S.
(II) 0·1093 " " 0·1447 " = 18·18 " "
Required S = 18·30 per cent.

ENARGITE (AsS_4Cu_3).

The oxidation was made in the same manner as in jamesonite:

0·1102 gram mineral gave 0·2449 gr. $BaSO_4$ = 30·52 per cent. S.

A second sample, oxidized with nitric acid, gave 31·00 per cent. S.

STEPHANITE (Ag_5SbS_4).

This mineral was oxidized without difficulty. The conditions under which it was worked were similar to those of the preceding minerals:

(I) 0·1044 gram substance gave 16·69 per cent. S.
(II) 0·1109 " " " 16·55 " " Theory req. 16·20 p. c. S.

KOBELLITE ($(Bi\ Sb)_2\ S_5\ Pb_2$).

The sulphur in this mineral was oxidized with ease:

(I) 0·1136 gram sub. gave 0·1562 gr. $BaSO_4$ = 18·38 per cent. S.
(II) 0·1157 " " 0·1594 " = 18·41 " "

The sample here oxidized was of the same material as that analyzed by Dr. Keller (*Proc. Chem. Sec. Franklin Inst.*, **1**, 127). On comparing the mean of his four sulphur determinations with the results obtained by the electrolytic method, it will be seen that the latter does not lack in completeness:

Current Oxidation.	*Nitric Acid Oxidation.*
Sulphur percentage.	18·37, 18·33, 18·46, 18·39
18·38—18·41.	Mean, 18·39 per cent. S.

TETRAHEDRITE ($(Sb,As)_2S_7(Cu_2,Hg_2,Fe,Zn)_4$.

Quite a number of sulphur determinations and complete analyses of tetrahedrite of the above composition were made in this laboratory during the college year just closed. In all of these the chlorine method was employed for decomposition purposes. The percentage of sulphur found was 24·48 per cent. Samples of the same were then exposed to the action of a current of two ampères for twenty minutes, and the sulphuric acid determined in the usual manner with these results:

(I) 0·1073 gr. mineral gave 23·81 per cent. S.
(II) 0·1096 " " 24·38 " "
(III) 0.1086 " " 24·23 " "
(IV) 0·1095 " " 24·37 " "

Tetrahedrite seemed to require the full time (twenty minutes) for oxidation, for in several instances, where the current was interrupted after acting fifteen minutes, the alkaline solution became quite turbid upon acidulation.

STANNITE (SnS_4Cu_2Fe).

The conditions here were the same as those already mentioned for the other sulpho-salts:

(I) 0·1087 gram mineral gave 28·61 per cent. S.
(II) 0·1091 " " 28·02 " "

PYRRHOTITE ($Fe_{11}S_{12}$), MARCASITE (FeS_2) AND PYRITE (FeS_2).

The sulphur in the first of these three minerals is very readily changed to sulphuric acid. None of its iron passes into solution, so that the barium sulphate, after ignition, was perfectly white in color. The residue, not soluble in water, showed no unoxidized sulphur:

(I) 0.1087 gram mineral gave 0·3049 gr. $BaSO_4$ = 38·51 per cent. S.
(II) 0·1067 " " 0·3014 " = 38·79 " "

By oxidation with nitric acid the sulphur found was 38·78 per cent. S.

An exceedingly pure specimen of marcasite was exposed to the action of the current. Its sulphur was rapidly and completely oxidized:

0·1043 gram substance gave 0·4056, gr. $BaSO_4$ = 53·40 per cent. S. Required S. = 53·33 per cent.

While these sulphides of iron parted with their sulphur with great ease, pyrite held half of its sulphur content quite tenaciously, notwithstanding it was exposed to the influence of much more powerful currents than the other two minerals.

(I) 0·1667 gram pyrite and 20 grams KOH were exposed for ten minutes to the action of a current giving one ampère per minute. The crucible served as anode for half the time. The sulphur that was oxidized equalled 24·53 per cent.

(II) 0·3080 gram pyrite, 30 grams KOH, and a current as in (I) gave 22 per cent. S.

A number of similar trials gave about the same results. As chalcopyrite was oxidized without difficulty (*Proc. Chem. Sec., Franklin Institute.* **1**, 53), the thought suggested itself that possibly the addition of cupric oxide might prove beneficial. Accordingly, the following experiments were made:

(III) 0·1009 gram pyrite, ·0611 gram CuO, 25 grams KOH, and a current of one and one-half ampères gave 36·39 per cent. S.

(IV) 0·1021 gram pyrite, ·0710 gram CuO, 25 grams KOH, and a current of one and one-half ampères gave 35·02 per cent. S.

(V) 0·1007 gram pyrite, ·0550 gram CuO, 25 grams KOH, and a current of one and one-half ampères gave 30·93 per cent. S.

The time in each trial was twenty minutes. While the addition of the cupric oxide apparently favors the sulphur oxidation, the results are anything but concordant.

(VI) 0·1000 gram pyrite, ·0950 gram CuO, 25 grams KOH, with a current of two ampères, for twenty minutes, gave 51·24 per cent. S.

(VII) 0·1000 gram pyrite, 0·1000 gram CuO, and other particulars the same as in (VI), gave 38·00 per cent. S.

The residues all contained unoxidized sulphur.

(VIII) 0·1045 gram pyrite, ·0523 gram CuO, 25 grams KOH, and a current of two and one-half ampères per minute, gave 46·93 per cent. S.

(IX) 0·1000 gram pyrite, ·0500 gram CuO, otherwise as in (VIII), gave 46·97 per cent. S.

(X) 0·1123 gram pyrite, 0·1400 gram CuO, 25 grams KOH, and a current of two and one-half ampères, gave 41·67 per cent. S.

(XI) 0·1160 gram pyrite, 0·1100 gram CuO, 25 grams KOH, and a current of two and one-half ampères, gave 51·26 per cent. S.

These examples are but a few of the many trials carried out to obtain all the sulphur. The final satisfactory results were obtained in the following manner:

(XII) 0·1060 gram pyrite, an equal quantity of cupric oxide, 28 grams KOH, and a current of four ampères per minute, gave 53·6 per cent. S.

The residue remaining, after treating the fused alkaline mass with water, was dissolved in nitric acid, diluted to 75 cc. with water, and tested with a solution of barium chloride.

No barium sulphate was precipitated on warming the solution, or even after allowing the same to stand for some days.

(XIII) 0·1048 gram pyrite, an equal quantity of cupric oxide, 28 grams KOH, and the current as in the preceding experiment, gave 53·02 per cent. S.

The residue did not contain sulphur. The time given for the oxidation in each of these experiments was twenty minutes, and the current was reversed after it had acted ten minutes.

Several trials were made with the view of ascertaining whether with conditions precisely analogous to those in the last two experiments, the copper oxide omitted, it would be possible to completely oxidize all of the sulphur. They proved failures. A current of five ampères, with cupric oxide absent, was insufficient for the complete conversion of the sulphur into sulphuric acid.

The sulphur of pyrrhotite was readily oxidized. Indeed, this mineral conducted itself very much like the monosulphides, zincblende, galenite, etc. Marcasite, too, offered no difficulty. Since it and pyrite differ only in crystalline form, can it be that the latter property alone is the cause of the greater stability of the pyrite? Will this explain its tenacious hold upon the sulphur? If this be true, why should not this stability extend to the two sulphur atoms? More than forty trials with pyrite show that it is only about half the sulphur which the current changes to sulphuric acid. At least such was the case when cupric oxide was not added. The same current strength that does this amount of oxidation with pyrite will convert *all* the sulphur in marcasite into sulphuric acid.

The writer would here acknowledge his indebtedness to Profs. Koenig and Keller for the mineral material consumed in this investigation, and also to Mr. D. C. Wallace for most valuable assistance in carrying out the oxidations and general analytical work.

UNIVERSITY OF PENNSYLVANIA,
Philadelphia, June 7, 1890.

NOTES AND COMMENTS.

CHEMISTRY.

THE CHEMISTRY OF TANNINS—C. Etti (*Monatsh*, **10**, 647 and 805, through *Journal of Society of Chemical Industry*).—The results of previous investigations have shown that the tannin $C_{17}H_{16}O_9$ obtained from *Quercus robur L*, and that obtained from *Quercus pubercens W*, occur in the oak bark not only in the form of tannic acid, but also as the anhydride; it was also found that the tannic acids, which are almost insoluble in water, do not occur in combination with a sugar, and are not therefore glucosides; their basis is not tannin, but a substance isomeric therewith, namely, a ketone acid (gallylgallic acid) of the constitution—

$$(OH)_3.C_6H_2.CO.C_6H(OH)_3.COOH,$$

formed from two molecules of gallic acid with elimination of one molecule of water.

In this paper the author gives an account of experiments, which show that the tannic acid $C_{16}H_{14}O_9$ is a derivative of the ketone acid referred to above; as this tannic acid closely resembles the acids previously investigated both in physical and chemical properties, it follows that they also are derivatives of the same ketone acid.

The greater part of the sparingly soluble ketone tannic acid occurs in the plant in combination with a metallic base, probably magnesium, and as these salts are very readily soluble in water, they can be easily and completely extracted. After concentrating the aqueous extract and acidifying with hydrochloric acid, the tannic acid is precipitated in an insoluble condition, and can be washed free from hydrochloric acid and then purified by extracting with alcohol or ether. The most suitable source of these acids are the commercial extracts, which are obtained from the bark and wood of various trees and largely used in tanning.

The author has isolated the following tannic acids by the method described above. An acid of the composition $C_{16}H_{14}O_9$ from the extract obtained by the Oak Extract Company in Slavonia, from the wood of the stalk-oak. An acid of the composition $C_{18}H_{18}O_9$ from the oak-bark used in a tannery at Pesth. An acid $C_{20}H_{22}O_9$ obtained from the bark of the copper-beech in the neighborhood of Salzburg. An acid of the composition $C_{22}H_{26}O_9$ from the hop cones obtained from Saaz. All these tannic acids have a different color, varying from brownish-red to bright red; those obtained from the stalk-oak and holm-oak give in dilute alcoholic solution a deep blue, the others, however, a green coloration with ferric chloride. It seems that all the tannic acids obtained from the oak are simply different derivatives of the same ketone tannic acid.

The tannic acid $C_{16}H_{14}O_9$ is a brownish-red amorphous compound; under the microscope it is seen to consist of small spherical nodules, which

are all so much alike that the presence of impurities can be easily detected. It is almost insoluble in water and ether, but readily soluble in alcohol and acetone. Its solution in dilute alcohol has an acid reaction, gives a precipitate with lead acetate and a dark blue coloration with ferric chloride. The formation of the phenylhydrazine-derivative, $C_{22}H_{20}N_2O_8$, and the oxime, $C_{16}H_{15}NO_9$, proves that the acid contains a ketone group.

When the acid is heated with dilute sulphuric acid at 120°–130°, it gives gallic acid (m. p. 238°–240°) and a large quantity of insoluble anhydro-derivatives. It forms a soluble neutral salt and several very sparingly soluble basic salts with magnesium. When heated alone at 130°–135°, or at 100°, with water in sealed tubes, or when boiled with hydrochloric or dilute sulphuric acid, it yields various very stable anhydrides, a property which is especially characteristic of the ketone tannic acids, and serves to distinguish them from tannin. When the acid is boiled with dilute (1–10) sulphuric acid, for example, as long as a red precipitate is produced it is converted into an acid anhydride, $C_{32}H_{24}O_{16}$, according to the equation—

$$2C_{16}H_{14}O_9 - 2H_2O = C_{32}H_{24}O_{16}.$$

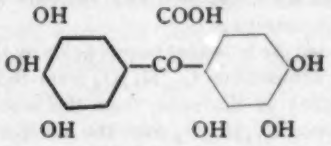
When heated at 120°–130°, under the same conditions, it gives two anhydrides. The one is soluble in ninety-six per cent. alcohol and is formed according to the equation—

$$2C_{16}H_{14}O_9 - 4H_2O = C_{32}H_{24}O_{14}.$$

The other is insoluble in ninety-six per cent. alcohol, and no longer contains a carboxyl group, its formation being expressed thus:

$$2C_{16}H_{14}O_9 - 5H_2O = C_{32}H_{18}O_{13}.$$

These experiments show that the tannic acid contains four hydroxyl groups; its behavior with hydrochloric and with hydriodic acid shows that it contains two methoxy groups. The acid, $C_{16}H_{14}O_9$, is therefore a dimethyl derivative of a ketone acid of the constitution—



but the position of the two methoxy groups has not yet been determined.

H. T.

On a new Reaction of Tannin—Dr. Carl Böttinger (Liebig's *Annalen*. No. 256, p. 341).—When tannin and phenylhydrazin are boiled together in watery solution in the proportion of 2 to 1 or better 1 to 1, or heated to 100° in the proportion of 1 to 2, with exclusion of water, a solution is effected, there occurs an evolution of gas, and a mixture of several bodies is formed. Some of these bodies are soluble in ether and some are not, the latter are not completely soluble in sodium hydrate solution, the ether-alcohol solution of the former is quickly decolorized by zinc dust and hydrochloric acid.

That portion of the above product which is soluble in ether and hot water has the property, when carefully treated with sodium hydrate, of giving a beautiful green-blue solution, the phenylhydrazin separating at the same time. Neither gallic nor pyrogallic acid gives this result.

The peculiar body which causes the above color is prepared by heating the tannin and phenylhydrazin, as above stated, in a water-bath for four hours, the watery solution is separated from the pasty precipitate and the latter dissolved in hot water, treated with hydrochloric acid and allowed to cool. To separate coloring matter, the solution is agitated with ammonia and then set aside for some time when it coheres. The separated solution is extracted with ether, evaporated, the residue heated with alcohol and the solution treated with ether, whereby phenylhydrazin chloride is precipitated and the body remains in solution. From water it crystallizes in colorless rosettes, which on exposure to air become yellow.

It is very soluble in hot water, and when once separated from solution dissolves in cold water with difficulty, it is easily soluble in warm alcohol, but slowly soluble in ether. Acetic acid readily dissolves it. Hot concentrated hydrochloric acid decomposes the pure body but slightly.

It is easily dissolved by warm phenylhydrazin. If this solution is mixed with acetic acid and warmed, there is formed an oily liquid easily soluble in ether, which dissolves in soda solution with a green-blue color.

Extract of sumac yields the same reaction with phenylhydrazin that tannin does, while oak-bark extract does not give it.

The compound obtained from gallic acid and phenylhydrazin is soluble in sodium hydrate solution with a reddish-yellow, orange or golden color.

H. T.

THE OXIDATION OF GALLIC ACID OF TANNIN AND OF THE OAK-TANNINS—Dr. Carl Böttinger (*Liebig's Annalen*, No. 257, p. 248).—The author, some years ago, showed that oak-bark red, as well as oak-bark phlobaphene, is decomposed by dilute nitric acid with considerable evolution of gas and the formation of oxalic acid and several other acids which can be separated from one another in the form of calcium salts. The yield of these acids, however, is small, scarcely amounting to six per cent. of the original material.

The first oxidation was carried out on the precipitate obtained by sulphuric acid on oak-bark extract, but so much calcium sulphate adhered to the salts as to render their purification impossible. It has also been shown that the oxidation products of oak-wood tannin of oak-bark red and of oak-bark phlobaphene are identical.

By the oxidation of gallic acid and tannin with nitric acid, there is formed a solution which, when treated with calcium carbonate, yields beside oxalate, two other calcium salts, one of which is almost insoluble in water, while the other is soluble. Gallic acid yields only a very small quantity of the former, but tannin rather more, which by estimation of its calcium showed it to be trioxyglutarate of calcium, with one molecule of water.

The easily soluble calcium salt was precipitated from its watery solution

by alcohol. The analysis of that from both the gallic acid and the tannin indicate it to be trioxybutyrate of calcium.

The oxidation of acetyl oak-wood tannin and of oak-bark red yielded trioxyglutarate insoluble, and soluble trioxybutyrate of calcium as determined by the analyses of these salts.

By varying the amount of nitric acid, easily soluble salts have been obtained, containing somewhat more calcium. H. T.

BOOK NOTICES.

A TECHNOLOGICAL DICTIONARY OF INSURANCE CHEMISTRY. By William A. Harris, F.R.S.S.A., F.S.S., etc.; Phœnix Fire Office. Liverpool: 1890.

This elaborate work of 407 pages, 8vo, by the well-known secretary, surveyor and insurance expert, who has long been connected with the Phœnix Fire Office, England, is well worthy of being a permanent book of reference in the offices of all fire insurance underwriters, their agents and brokers throughout the world, also in the offices of all fire-extinguishing departments and insurance patrols in cities and towns. It is on same plan as Mr. Harris' *Dictionary of Fire Insurance*, which was reviewed some months ago in this journal. The present work, however, has special reference to spontaneous ignition and the chemical causes thereof; also intended to aid in clearing from the records of fires some of the too numerous "unknown" causes.

The principal subjects treated are "Spontaneous Combustion, Oxidation, Chemical Affinity, Fermentation, Friction, Expansion of Gases, Inflammability of Vapors, Dust Explosions, Steam Heating and Drying, Oils, Fibres Coal, Cotton, Mixed Cargoes, etc., with actual cases showing where losses have occurred; also miscellaneous chemical and physical information."

A few illustrations will show more clearly the intention of the work: Naphtha is given about three-quarters of a page. Though the fact is known to specialists, it is not generally known that the electric spark will ignite naphtha vapor, when a glowing coal or lighted cigar will not do so. Naphtha and turpentine burn more fiercely on the moderate application of water: they must be deluged or a wet blanket applied at the earliest moment. Illuminating gas may be fired by red-hot metal, but to ignite hydrogen a flame (though it may be excessively small) is required. In naphtha drying-rooms, where the vapor is present, fires have been occasioned while scraping the floors, by the iron scraper striking a spark on a nail. Had an instrument of phosphor-bronze (whose chief component is copper) been employed, no spark would have resulted from such contact.

Much space is given to the danger from ignition of oiled rags and oiled waste, with some instructive examples of fires caused thereby and by oils, oxidation of oils and oxidation in general. Some of the other subjects liberally treated and exemplified in this technical dictionary are: Coal tar, nitre, quicklime, cotton, cotton cargoes, cotton compressing and bagging,

cotton fires from friction and in various localities (including two pages for the circular issued by the National Board of Marine Underwriters, of New York, respecting cotton cargo fires and means to use when they occur) also modes of ventilating dangerous cargoes, besides jeorpardy arising from sawdust, steam pipes, varnish and various acids in commercial and industrial use.

A great amount of valuable information is given respecting numerous chemicals, and their influence in causing or increasing ignition. The few citations above made will show the practical nature of the subjects treated; and the mode in which they are handled renders them peculiarly available for popular use. N.

METHODS OF REDUCING THE FIRE LOSS. By C. J. H. Woodbury. Boston: Brochure, 33 pp.

This pamphlet publishes a paper read before the American Society of Mechanical Engineers, and contains some excellent suggestions for the correct care of industrial establishments in particular, also much information respecting proper construction of industrial buildings. What is known as the "slow-burning mode of construction" for floors, ceilings, roofs and partitions is strongly advocated, as it well deserves. There are also discussed, automatic dampers for dust flues, spontaneous ignition of bituminous coal, fire apparatus in general and sprinklers in particular. The author favors one-story factories, especially for cotton and woollen mills, and gives some illustrations thereof. This brochure will be of advantage to any owner or manager of an industrial establishment. N.

SLIDE-VALVE GEARS.—By Frederic A. Halsey. Analysis by the Bilgram Diagram. New York: D. Van Nostrand Company, 1890, pp. viii, 135.

As usual, this work has been prepared to meet a real want, and the author considers a mathematical treatment an uncalled-for use of heavy artillery. He finds it necessary to use, however, about the same amount of mathematics any one else requires to cover the same ground, as on p. 28, he says that the demonstration of the Bilgram diagram depends upon a theorem of geometry which he loosely states.

In the preface, the comparison made between the Zeuner and the Bilgram diagram is simply an evidence of the fact that the author does not know what he is talking about. He says: "Valve diagrams are used * * * to analyze existing valve motions and to design new ones. The Zeuner diagram fulfils the first purpose perfectly, but is unsatisfactory when applied to the second." The author evidently means unsatisfactory to him, as from the context it is evident that his knowledge of the Zeuner diagram is limited. "The leading data that are given in designing a valve motion are the point of cut-off, the port opening, and the lead of the valve (not the lead angle of the crank, as is often conveniently assumed). It is the radical defect of the Zeuner diagram that none of these dimensions can be laid off from known points * * * the result sought is only found through blind trial. With Mr. Bilgram's method all this is changed. The lead is laid off from a fixed